Power Transmission Engineering®

APRIL
2024

COUPLINGS FOR ROBOTICS & AUTOMATION

PLANETARY GEARBOX UPGRADE

MASTER POWER TRANSMISSION PARTNERS WITH READY ROBOTICS

AUTOMATE 2024

TECHNICAL

Gear Reliability Data
Load Collectives

How can an enhanced HMI be so affordable?

Simple, it's a C-more HMI from AutomationDirect!

NEW! CM5 Series High-performance HMIs

The NEW C-more CM5 HMI series offers low-cost, high-performance HMIs in sizes from 4 inches **(only $340.00)** to an impressive 22 inches **(only $2,299.00)**. With an amazing 1.6 GHz processor in the larger units (10" and above) and 90 Mbytes of memory, these HMIs provide better trending, extra data storage, faster communication, improved file types, and 16.7 million screen/object color options.

All CM5 panels have serial and Ethernet ports (dual Ethernet ports on 10" or larger models) that support many of the most popular industry protocols, including EtherNet/IP, MQTT, and Modbus. The included USB ports provide in-an-instant connections for keyboards, barcode scanners, memory storage, etc. and the embedded SD-card slot provides easy project transfers or up to an additional 2TB of data storage (depending on model) for important log files.

Plus, all C-more HMIs come with **FREE,** powerful, easy-to-use programming software and **FREE** technical support!

HMIs starting at only:

$340.00

ftp. www USB SD™

MQTT EtherNet/IP™

Research, price, buy at:

www.automationdirect.com/cmore

Order Today, Ships Fast!

TOP RATED BY CUSTOMERS

AUTOMATIONDIRECT.com

1-800-633-0405

the #1 value in automation

Power Transmission Engineering®

APRIL 2024

Power Transmission Engineering is POWERED by The American Gear Manufacturers Association

FEATURE ARTICLES

TECHNICAL ARTICLES

STAY CONNECTED

Connect with us on LinkedIn
linkedin.com/groups/Power-Transmission-Engineering-PTE-2950055

Subscribe Online
powertransmission.com/subscriptions

Vol. 18, No. 3. POWER TRANSMISSION ENGINEERING (ISSN 2331-2483) is published monthly except in January, May, July and November by The American Gear Manufacturers Association, 1001 N. Fairfax Street, Suite 500, Alexandria, VA 22314, (847) 437-6604.

Periodicals Postage Paid at Elk Grove Village IL and at additional mailing offices.

Power Transmission Engineering®
VOL. 18, NO. 3

IMTS2024
INSPIRING THE EXTRAORDINARY

"I have visited hundreds of shops. **All the top shops take the time to go to IMTS** to see what is possible."

I AM A VISIONARY

#IAmIMTS

Matt Gawlik | 3D Graphite & Machining Inc.

WHAT WILL YOU ENVISION AT IMTS?

Manufacturing visionaries come to **IMTS – The International Manufacturing Technology Show** to connect, find inspiration, and discover solutions.

Join me at McCormick Place in Chicago from September 9-14, 2024.

REGISTER NOW

PTE REVOLUTIONS
Mechatronic Methodology

IIjin Electric's collaboration with Siemens Digital Industries began with the company's efforts to effectively integrate electrical design with mechanical design. The collaboration has continued to evolve over time and has contributed to IIjin Electric's establishment as a technology leader in the global market.

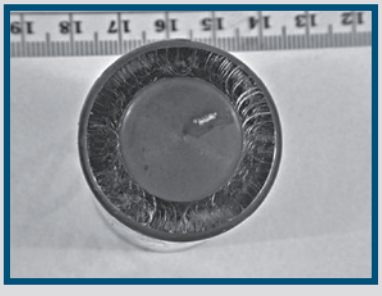
powertransmission.com/blogs/l-revolutions/post/9708-mechatronic-methodology

R+W WHITEPAPER
Precision Line Shafts–More Widely Used Thanks to Localized Production

All-in-one precision line shaft couplings are fast becoming the most popular method of synchronizing motion between belt drive and screw jack actuators, thanks to improved accessibility and shortened lead times.

powertransmission.com/ext/resources/white%20paper/How-US-Manufacturing-of-Precision-Line-Shafts-is-Influencing-Mechanical-Design-RW0324.pdf?1708962160

AS SEEN IN *GEAR TECHNOLOGY*
Morphology of Wear on Tapered-Roller Bearing Roller Ends and Thrust Ribs



This report investigates the wear morphology on the large end of tapered rollers and the inner ring's large end rib on a planet carrier TRB from a multi-megawatt wind turbine gearbox.

geartechnology.com/articles/30599-morphology-of-wear-on-tapered-roller-bearing-roller-ends-and-thrust-ribs

powertransmission.com

AGMA MEDIA
1840 Jarvis Avenue
Elk Grove Village, IL 60007
Phone: (847) 437-6604
Fax: (847) 437-6618

EDITORIAL
Publisher & Editor-in-Chief
Randy Stott
stott@agma.org

Senior Editor
Matthew Jaster
jaster@agma.org

Senior Editor
Aaron Fagan
fagan@agma.org

GRAPHIC DESIGN
Design Manager
Jess Oglesby
oglesby@agma.org

ADVERTISING
Advertising Sales Manager & Associate Publisher
Dave Friedman
friedman@agma.org

Materials Coordinator
Dorothy Fiandaca
fiandaca@agma.org

CIRCULATION
Circulation Manager
Carol Tratar
tratar@agma.org

MANAGEMENT
President
Matthew Croson
croson@agma.org

FOUNDER
Michael Goldstein founded *Gear Technology* in 1984 and *Power Transmission Engineering* in 2007, and he served as Publisher and Editor-in-Chief from 1984 through 2019. Michael continues working with both magazines in a consulting role and can be reached via e-mail at *michael@geartechnology.com.*

cti symposium US

AUTOMOTIVE · PROPULSION · SYSTEMS

International Congress and Expo I 15 – 16 May 2024, Novi, MI, USA

BE PART OF IT

THE EXPERT SUMMIT FOR A SUSTAINABLE FUTURE MOBILITY

Abey Abraham
Ducker Carlisle

Mike Anderson
General Motors

Micky Bly
Stellantis

Christian Feldhaus
ZF

Taylor Hansen
Webasto Thermo & Comfort

Dhanashree Kad
ZF

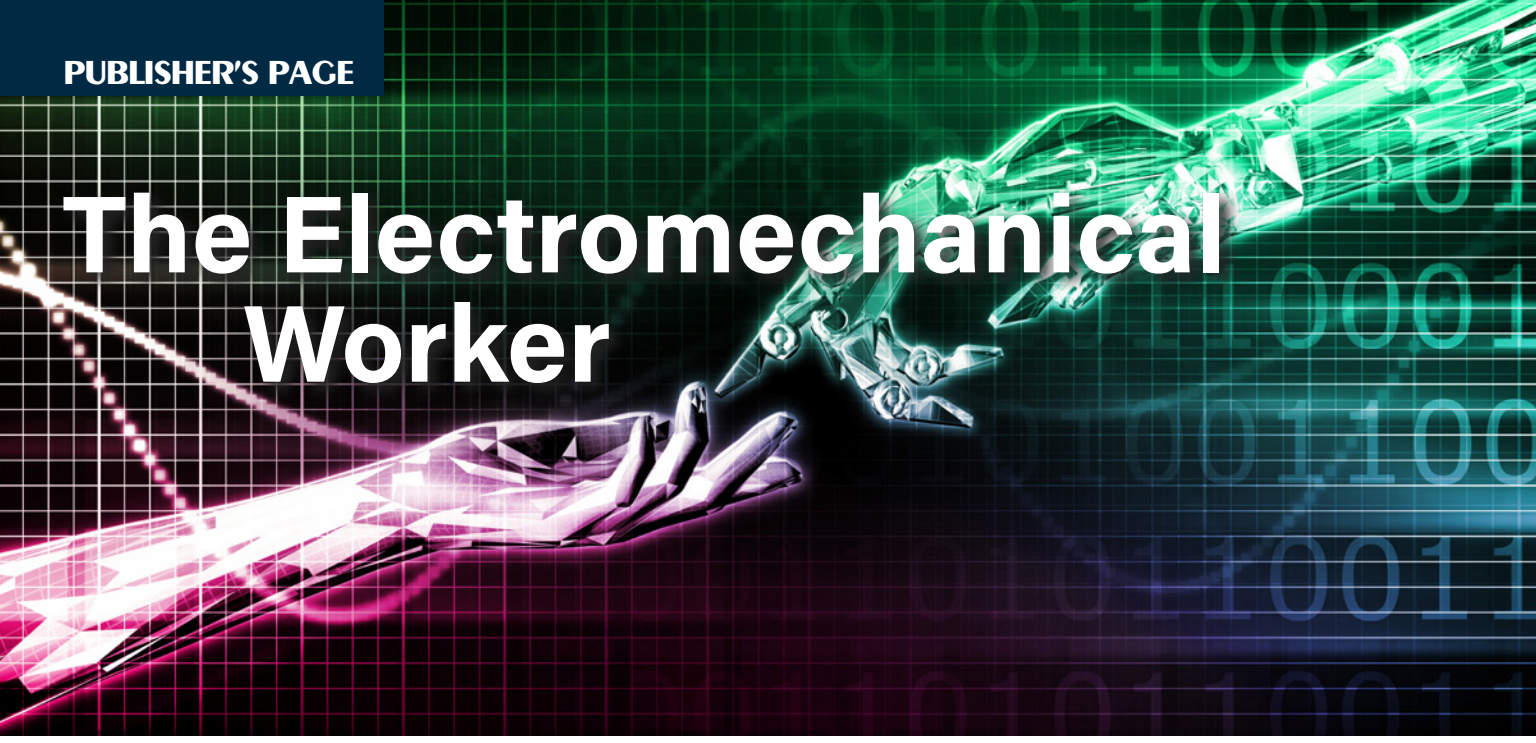
Jonathon Ratliff
Nissan Technical Center
North America

Celina Mikolajczak
Lyten

Brian Schneidewind
Toyota North America

Matthew Vachaparampil
Caresoft Global Technologies

cti-symposium.world/us
#CTI_sym



The Electromechanical Worker

At the AGMA/ABMA annual meeting (held March 15–17 in Napa, CA), gear manufacturers, bearing manufacturers and industry suppliers spent a lot of time talking about one of the key issues affecting all of industry: finding and retaining skilled employees.

I hear about a lot of different approaches people are taking, including cooperations with local educational institutions, such as high schools, community colleges and technical trade schools. I heard the competition for dedicated young employees who are interested in joining a manufacturing team is so fierce that many companies who want to hire simply can't. Some have even begun creating their own in-house training and education programs at least partially in order to bypass that competition and find and develop the necessary talent.

Almost everyone I talked to said they would hire more people if they could. Even at a time when industry growth has stalled or even ground to a halt, nobody is talking about layoffs, closures or shutdowns. Everybody is hiring, or at least trying to do so.

It's no surprise, then, that interest in robotics and automation is skyrocketing. By automating processes, you can maintain or increase your levels of productivity without adding labor.

This issue, many of our articles touch on this theme.

For example, the article "Easy Integration" (p. 16) talks about how smart couplings and brakes from Mayr help enhance the safety of cobots and other lightweight robots.

We also have a great feature article (p. 20) from Ready Robotics and Master Power Transmission about how robotics can be effectively introduced, even in a low-volume, high-mix environment, to enhance efficiency, optimize labor and promote sustainable practices.

Finally, Senior Editor Matt Jaster gives us a preview of the upcoming Automate 2024 trade show with his article, "The Flexible Factory," where he covers mobile robots, cobots, artificial intelligence and many other technologies that will be on display when the event comes to McCormick Place in Chicago, May 6–9.

Automation won't solve all of industry's skilled labor issues. No matter how much you're able to automate, you're still going to need skilled people to operate the technology you've implemented. Unfortunately, finding and retaining those skilled people doesn't seem like it's going to become easier any time soon.

But implementing technology has always been a key to improving productivity, efficiency, quality and safety, and doing those things are the hallmarks of remaining competitive. So it behooves every manufacturer to continue the process of improving operations. Clearly, automation has to be a big part of the solution.

I'm interested to know what the rest of you are doing in your industries to increase automation. Are your efforts paying off? Are they relieving the pressure of not having enough skilled workers? How much more can you automate, and what have you tried so far?

Drop me a line at *stott@agma.org*. I'd love to hear about your experiences with implementing automation and robotics, and to learn more about your challenges and success stories.

PTE

Randy Stott
Publisher & Editor-in-Chief

SETTING IDEAS INTO MOTION

Engineering Development & Manufacturers of Small Mechanical Components

Manufacturing Precision Gears, Mechanical Components, and Custom Solutions

- In-house engineering and manufacturing in the USA
- World-class quality
- ISO 7 Class 10000 Clean Room
- Assembly
- AS9100:D + ISO 9001:2015 Registered
- ITAR Compliant / DDTC Registered

SDP/SI

STOCK DRIVE PRODUCTS/STERLING INSTRUMENT

Place a RFQ Online

www.sdp-si.com

Call our Engineers Today!

1 (516) 328-3300

100,000 Mechanical and Electromechanical Components

- Shop 24/7
- 3D CAD models
- Competitive pricing
- Customizable

BECKHOFF AUTOMATION

Provides Servo Drive Technology for Precision Machining

In Watch Valley, a region between Basel and Geneva, an ecosystem has developed over several centuries around the watch industry and the smallest precision components for micromechanical devices. Machine builders such as Esco SA in Les Geneveys-sur-Coffrane and Affolter Group SA in Malleray are an important part of this ecosystem. Their CNC machines are used to manufacture the smallest gears, screws, shafts, and other components at maximum precision, practically laying the foundation for the famous precision of Swiss watch movements.

Esco specializes in lathes to produce parts with high accuracy and impeccable quality in medium and large quantities. As well as turning as their main process, the machines offer additional machining functions. They make it possible for complex parts to be produced on compact machines.

Stationary Material and Rotating Tools

Unlike conventional automatic lathes, Esco machines are characterized by an individual operating principle: stationary material, rotating tools. This allows the machines to process ring or bar material in a fully automated process without interruptions. "In addition, the proximity of the tools to the workpiece offers advantages in terms of production rate and surface quality," says Vincent Fankhauser, sales manager at Esco. The basis for the precision and the short machining times is the spindle, which rotates at up to 12,000 rpm.

Esco has been relying on PC-based control for the automation of its machines since the beginning of 2020, for which it uses TwinCAT 3 from Beckhoff. "The control and drive technology from our previous suppliers were at the end of their life cycle and we needed future-proof CNC technology that could be easily configured for our different series," says Vincent Fankhauser.

This is where Affolter comes into play. The company manufactures gear hobbing machines itself and, as a contract manufacturer, produces intricate parts for the watch industry and other sectors on around 350 machines. Managing Director Vincent Affolter: "We were always proud of our own control solution, which we developed ourselves for our machines and then had the electronics manufactured." The central component of the control system was an FPGA that calculated all setpoints for all axes in parallel within microseconds. But when the electronic components became unavailable, Affolter was no longer able to maintain its control system, let alone develop it further and integrate additional requirements such as IT connectivity. Fortunately for Affolter, the performance of PC technologies was increasing rapidly.

From FPGA to Open Control Platform

"When analyzing possible control system suppliers in 2016, we quickly found what we were looking for at Beckhoff and started initial tests with PC-based control," says Vincent Affolter. One of his priorities was to retain the flexibility for in-house innovations without the company having to develop hardware itself again. "This is provided by the open control platform from Beckhoff," adds Philippe Abt from sales at Beckhoff Switzerland. PC-based control and TwinCAT CNC now form the basis for a control platform that Affolter uses in their own CNC machines and makes available to machine builders such as Esco.

When adapting the CNC solution to the Esco machines, the flexibility of

Esco relies on a control solution based on TwinCAT CNC developed by the Swiss Beckhoff Solution Provider Affolter across all machine series.

The C6920 control cabinet Industrial PC (right), which runs the TwinCAT CNC for up to twelve servo axes and spindles, and the associated EtherCAT Terminal system (left).

PC-based control became apparent: due to the required machine cycle, there was no time to waste when processing the CNC tasks. "Due to the modular system architecture of TwinCAT CNC, it was possible to achieve the short cycle times required by Esco by configuring it accordingly," recalls Abt. In order to reduce the computing times for the tasks, any functions that were not required were removed. "The crucial thing for us is that we have always received support in this from the very beginning, and have found and implemented solutions together with Beckhoff. That is not something that can be taken for granted," says Affolter.

PC-Based Control Suitable for All Series

The jointly adapted control concept based on TwinCAT 3 and a C6920 control cabinet Industrial PC works in all Esco machine series and forms the basis for the long-term and safe migration of all CNC machines to PC-based control. In total, Esco has already delivered around 150 machines with TwinCAT CNC-based control technology in various configurations since 2020. As Vincent Fankhauser says: "We are now much more flexible and can put together exactly the computing power and drive configuration we need from the entire portfolio, including safety." With an Escomatic D6 Twin, for example, there are twelve servo axes to be controlled and three CNC channels to be calculated.

The One Cable Technology (OCT) in the drive technology (AX5000 Servo Drives and AM8000 servo motors) saves space in the control cabinet and in the machine, since only one, thinner motor cable needs to be routed. The issue of signal interference in the

Different CNC machine, same control core: Affolter synchronizes three high-speed spindles with PC-based control from Beckhoff in its own machining centers.

Control for the lathes: The C6920 control cabinet Industrial PC (right), which runs the TwinCAT CNC for up to twelve servo axes and spindles, and the associated EtherCAT Terminal system (left).

feedback systems has also been eliminated since the switch to OCT.

Affolter and Esco are currently working on integrating tool monitoring and inline quality control. The roadmap also includes the connection of their CNC machines to MES and ERP systems via umati (universal machine technology interface) and OPC UA. With PC-based control as an open and modular control system, this is set to be another success.

beckhoff.com

FVA-WORKBENCH

Version 9 Redefines Gearbox Design

With the release of version 9, the *FVA-Workbench* once again sets new standards in gearbox design, enabling the seamless integration of the latest research results into industrial practice. As a groundbreaking interface between collective research and application, the *FVA-Workbench* accelerates development and innovation in drive technology. This new release is more powerful than ever, with innovative features for flexible load spectra and improvements in FEM components and shaft-hub connections.

New Features in *FVA-Workbench 9*

Flexibility in Load Spectrum Calculations: Individual Power Paths for Each Load Stage

One new feature of *FVA-Workbench 9* is flexible load spectrum calculations. In contrast to the previous method, in which the power was scaled across different load stages, this function makes it possible to define different operating states. Individual power paths and additional loads can be assigned to each operating state, particularly for consideration of auxiliary units. The time share, operating temperature, switching position, power flow data, and external loads can be freely selected for each load case. This data can easily be copied and pasted from *Excel*. A model snapshot can also be created for each load case, with detailed results that can be displayed in the overview tables in the report.

Efficient Integration of Gearbox Housings: Error Prevention and Faster Workflows

The latest version of the *FVA-Workbench* includes new FEM features, especially with regard to split FEM gearbox housings. Gearbox housings can now be imported as an assembly of individual CAD components and linked together. This not only helps to avoid errors when merging CAD components, but also saves time thanks to coarser meshing of less critical components. The housing components are shown individually in the Model Tree to minimize errors and simplify the overall process.

Detailed Calculations for Interference Fits: Elastic-Plastic Material Models

In addition to several user-friendliness improvements, the stress hypotheses for tapered and cylindrical interference fits have also been expanded in

FVA-Workbench 9. Calculations can now be performed according to the von Mises shape modification hypothesis in addition to the DIN 7190 shear stress hypothesis. This allows for the consideration of strain hardening curves to represent the material behavior more accurately during partial plastification.

More than just Software—a Bridge Between Research and Industrial Practice

The *FVA-Workbench* enables engineers to easily visualize complex relationships, simplifies the simulation and analysis of influencing factors, and automates processes. From conception to optimization—the software offers comprehensive approaches for all phases of gearbox development. The underlying calculation methods are based on the results of German research and are supported by the expertise of FVA members.

fva-service.de

ABB

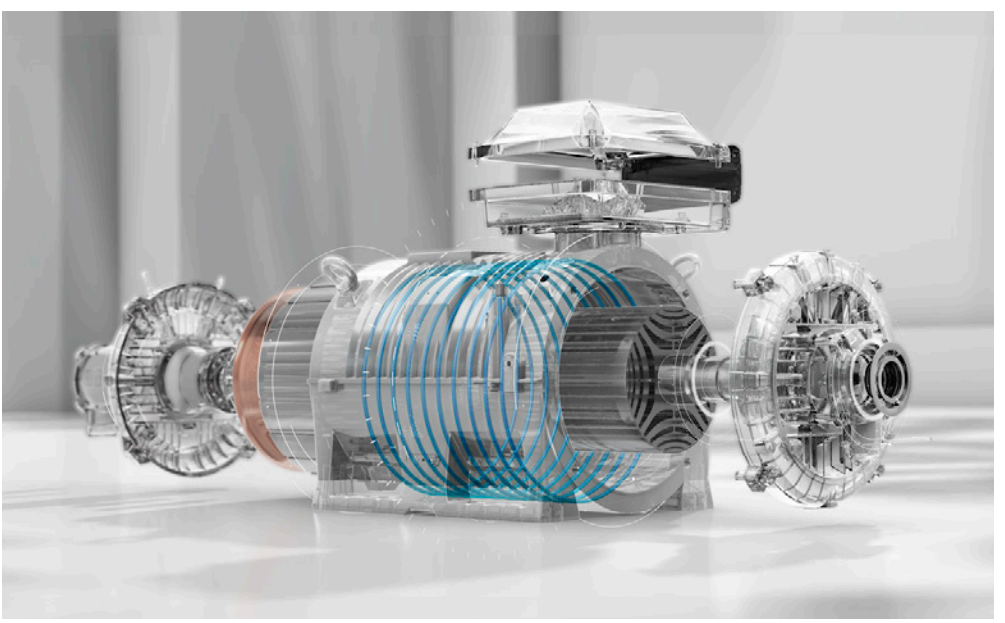
IE5 SynRM Motor Provides Energy Efficiency and High-Power Output

ABB has launched a new version of its IE5 SynRM (synchronous reluctance motor) series that combines the benefits of ultra-premium energy efficiency with highly effective liquid cooling. The new design sets a new benchmark for high power output and reliability in a compact footprint.

Customers can use IE5 SynRM Liquid-cooled motors to save energy costs and cut emissions in new projects or as a drop-in replacement for less efficient motors. They are ideally suited to a wide range of industries including marine propulsion, rubber and plastics production, and food and beverage.

A major advantage of the IE5 SynRM Liquid-cooled motors is that they are much more efficient than the traditional liquid-cooled induction motors in current use that offer significant potential for upgrading with energy-saving technology. Energy efficiency is crucial to optimizing the total cost of ownership (TCO) of an electric motor because the cost of the energy to run it throughout its life accounts for around 97 percent of a motor's TCO, with the purchase cost accounting for about two percent. IE5 motors have 40 percent lower energy losses than commonly used IE3 motors. This makes the payback time for selecting an IE5 instead of an IE3 motor often less than one year.

Reliability is improved by highly effective cooling combined with the cool SynRM rotor and cooling ribs on



the bearing assembly that reduces the operating temperature of the bearings. This helps to increase the lifetime of this key component and reduce maintenance needs.

The motors are robust, with tight seals to keep out moisture, dirt and dust, and a smooth outer surface to prevent dust build-up. This makes them perfect for demanding applications that require high power density where space is restricted such as marine propulsion systems and thrusters. Furthermore, the motors do not need fans or ventilation, so they do not disturb the surrounding air or release heat into the local environment. This is a major benefit in processes that are impacted by airflow, such as rubber and plastics production, and food and beverage applications like chocolate conche machines. With no fans, the motors also enhance the working environment by reducing noise levels.

Stefan Floeck, Division President IEC Low Voltage Motors, ABB, says: "ABB pioneered both SynRM technology and liquid cooling for induction motors. Now we have brought them together in our IE5 SynRM Liquid-cooled motor that enables customers to enjoy the benefits of ultra-premium efficiency in an even wider range of applications. It is yet another world-first for this series following the launch of our IE5 SynRM Increased Safety motor for hazardous areas."

abb.com

RULAND
Offers Inch-to-Metric Rigid Couplings

Ruland Manufacturing now offers rigid couplings with inch-to-metric bores as a standard product, giving users a wider range of off-the-shelf couplings. This expansion is the latest addition to the company's inch-to-metric, standard coupling product line that includes seven types of motion-control couplings and universal joints. Instead of re-machining or ordering custom-made couplings, using off-the-shelf, inch-to-metric rigid couplings saves time and money.

Ruland rigid couplings often are used to connect motors or gearboxes to ball screw or lead screw linear actuators. Many designers prefer them because they have higher accuracy and can transmit significantly more torque than equivalently sized flexible couplings. One-piece style couplings allow for a simpler installation, while the two-piece style has a balanced design for smoother operation at speeds up to 4,000 rpm. Ruland supplies clamp-style couplings with premium hardware that test beyond ISO strength class 12.9 standards. They also have Ruland's proprietary Nypatch anti-vibration coating to maintain holding power and torque capabilities in most industrial operating environments.

"Ruland is well known in the flexible coupling world for having the widest range of standard bore sizes, including inch-metric options," says Bill Hewitson, president of Ruland Manufacturing. "Expanding our rigid coupling line to incorporate these inch-metric combinations gives engineers designing with Ruland products more flexibility to use the coupling that best fits their application, be it a rigid or flexible type."

Ruland manufactures couplings from meticulously selected North American bar stock in 2024 aluminum for lightweight and low inertia, 1215 lead-free steel for the highest torque capacity, and 303 stainless steel for corrosion resistance. Rigid couplings are made in Ruland's ISO 9001:2015 certified manufacturing facility in Marlborough, Massachusetts, under strict quality controls using proprietary processes. The couplings are RoHS3, REACH, and Conflict Minerals compliant.

ruland.com/rigid-couplings.html

NORD DUODRIVE
Receives UL/CSA Certification

Nord Drivesystems announces that their DuoDrive integrated gear unit and motor has received UL/CSA certification. This unit combines a high-efficiency IE5+ synchronous motor and single-stage helical gear unit into one compact housing with a smooth, easy to clean surface. This design concept delivers an extremely high system efficiency of up to 92 percent and offers a solution to the increasing demand for energy-efficient drives, particularly in the intralogistics, pharmaceutical, and food and beverage industries.

DuoDrive is available in two case sizes (SK EVO 80 and SK EVO 200) and offers a power range of 0.5–4.0 hp, speeds up to 3,000 rpm, and torque up to 2,186 lb-in. Easy connection to applications is possible thanks to flexible attachment options such as B5 or B14 flange, torque arm, shrink disc, and Gripmaxx. Its Plug-and-Play capabilities enable simple, quick commissioning and maintenance for greater system availability.

The integration of IE5+ synchronous motor technology delivers multiple advantages and benefits to the drive including high energy efficiency, high system overload capacity to handle heavy loads in intralogistics, quiet operation, reduced operating costs, and a lower Total Cost of Ownership (TCO). Constant torque over a wide speed range reduces the number of system variants, eliminating the need for backstock of multiple parts and products and enabling easier system maintenance.

The DuoDrive is also available in a hygiene-friendly version for

pharmaceutical and food and beverage applications. Along with the smooth, easy to clean aluminum surface that offers high corrosion resistance, this version features a significantly smoother gearbox cover. Additional options such as a stainless round connector (MRS VA), hygienic gear cover (HYGA), IP69K protection, stainless-steel gland, and stainless-steel output shaft are also available and recommended for use in wash-down environments.

Nord's innovative DuoDrive integrated gear unit and motor is available for global use and complies with CE, UKCA, EAC, UL, and CSA certifications and approvals.

nord.com/us/products/gear-units/duodrive/pdp_duodrive_156740.jsp

VOITH
Provides Inline Thrusters for Superyacht

Spanning more than 118 meters long, Liva, delivered in August 2023, is the largest superyacht to date built by the prestigious Abeking & Rasmussen shipbuilder in Lemwerder, Germany, near Bremen. However, its length is by no means the only record-breaking feature that the shipyard offers in the superyacht segment. The sleek black hull is a visual highlight that draws the observer's gaze to focus entirely on the elegant silhouette. All technical necessities are accommodated in a way that makes them as invisible as possible.

These features are capped off with a sophisticated diesel-electric propulsion system, designed for exceptionally quiet operation to deliver a high level of comfort on board. The elementary building blocks of this concept include four Voith Inline Thrusters 1000-300 (VIT). At 300 kW each, they help ensure exceptionally quiet maneuvering.

Since its introduction in 2008, the VIT has proven effective in numerous maritime applications. The popularity of the system is based among other things on its compact design, extremely low-vibration operation, fast responsiveness, and low maintenance requirement.

In the VIT, a rim-driven propeller is driven by a permanent magnet electric motor. The system works without a drive shaft or transmission. The propeller is mounted on a seawater-lubricated slide bearing patented by Voith. This technology ensures a compact design, low vibrations, and extremely quiet running. The specially developed blade geometry also reduces cavitation and helps minimize vibrations and noise.

Thanks to its design, the VIT has very few wear parts. Moreover, the propeller blades can be replaced individually and underwater. These

two features allow uncomplicated and cost-efficient maintenance.

"The VIT is the perfect drive system for vessels whose passengers expect an especially high level of comfort. The extremely quiet operation ensures an exceptionally comfortable stay on board, while the design principle guarantees continuous reliable operation," says Oliver Lenz, sales application manager at Voith.

Abeking & Rasmussen has been working closely with Voith for many years and has already used innovative drive concepts from Heidenheim in countless vessels. For example, the three new Scharhörn-class multipurpose vessels built for the German Federal Waterways and Shipping Administration in 2021 are also equipped with VIT systems.

voith.com

IGUS

Launches iglide i230 3D Printing Material for High-Temp Applications

Igus announces its new iglide i230 3D printing material for selective laser sintering (SLS). This new powder material can withstand temperatures up to 110°C, expanding the use cases for SLS-printed polymer components.

During SLS, a printer melts plastic powder layer by layer to form bearings and other components. However, parts made from standard SLS printing materials—such as PA (nylon) 12—are generally limited to applications less than 80°C. Higher temperatures cause the material to become soft and lose dimensional stability, preventing SLS-printed components from being used in applications like automotive engines.

"As the demand for 3D-printed plain bearings for applications with high ambient temperatures has increased, we have developed a new SLS printing material called iglide i230," says Paul Gomer, 3D printing material developer at igus.

Tests performed according to DIN EN ISO 75 HDT-A and HDT-B have demonstrated iglide i230's heat resistance. Printed parts made from the material do not deform at 80°C. They can withstand long-term exposure to temperatures of 110°C—and even short-term exposure to 170°C without deforming.

"3D-printed plain bearings made from iglide i230 have a significantly longer service life, increase the efficiency of machines, systems and vehicles and reduce the need for maintenance," says Gomer.

At the same time, iglide i230 offers 50-percent more mechanical strength than PA 12 at room temperature.

"This makes it possible, for example, to achieve the same component strength in plain bearings with a thinner wall thickness and to save room and weight in compact installation spaces," emphasizes Gomer.

igus.com

APPLIED MOTION PRODUCTS

Introduces M5 Servo Series

Applied Motion Products introduces the M5 Servo Series—where power, precision, and cost-efficiency converge. The M5 Servo Series is engineered for high machine performance, exceptional torque output, and precise control. This series is optimized for cost-efficiency, ensuring peak capabilities without compromising performance.

M5 servo drives implement accurate motor control algorithms. When paired with our M5 motors' high-resolution encoders, they result in smooth and precise motion control. It supports fast motion profiles, automatic error compensation, and troubleshooting aids to achieve high system throughput and minimize downtime.

"The M5 series servo motors and drives with fast dynamic response, advanced safety features, and a broad range of industrial network options represent an unrivaled combination of performance and cost-effectiveness for our customers," Don Macleod, CEO of Applied Motion Products.

To support OEM designs, a comprehensive range of mechanical customizations is available for all high-power density servo motors and drives.

The M5 Servo Series balances cost-effectiveness with performance. It offers a versatile range of options, competitive pricing, and premium components.

applied-motion.com/s/m5-servo-motor-and-drive-series

PRECISE. ROBUST. AVAILABLE.

CD® Couplings

- Zero-Backlash & High Torsional Stiffness
- Engineered Performance for Reliable 24/7 Operation
- Servo-Rated for Reversing, Positioning & Precision
- Single-Flex, Double-Flex, Floating-Shaft Solutions
- Standard Models / Fully ***Customizable***
- Engineering Assistance / ***Fast*** Delivery

www.zero-max.com 800.533.1731

ZERO-MAX®

Easy Integration

Mayr components offer flexibility and guidance in robotic and automation applications

Ralf Epple, Head of Product Management, Mayr Power Transmission

ROBA-ES elastomer couplings from Mayr Power Transmission.

There is no compromise to safety in robotic applications. Lightweight robots or collaborative robots (cobots) are capable of complex and unexpected movements and need to stop immediately ensuring the safety of human operators. This is where smart couplings and smart brakes provide intelligent flexibility and guidance.

For this reason, robot arms must come to a standstill as quickly as possible in the event of an emergency or safety stop and must not descend in an uncontrolled manner after the power is switched off or in the event of a power failure.

Precision-Based Drive Technology

Robotics applications require a high degree of precision; gripper arms, for example, must be positioned exactly. Shaft couplings from Mayr Power Transmission therefore guarantee a backlash-free, precise connection across all coupling types: this applies to steel disk couplings as well as to elastomer or metal bellows couplings.

These couplings are also optimized for installation space and are very power-dense. All these requirements are covered by Mayr's standard modular system. Users can put together the right product with just a few clicks using the company's configurator. In addition, unique designs are also possible for special requirements. In general, our experience shows that no uniform standard has yet been established in the robotics and automation sector. Mayr has a wide variety of coupling variants currently in use.

We started making our shaft couplings 'smart' more than 15 years ago. The idea at the time was that shaft couplings are needed in every drivetrain. This means that they are deployed right where the action is, so to speak.

What if a coupling that was already there could now 'talk' and provide information about its status? Instead of adding complex measuring flanges or similar devices to the drivetrain, we have equipped the couplings with integrated sensors. This saves space and additional components.

Advanced Sensor Technology

This approach is particularly attractive in the field of process monitoring, where both accuracy and economic efficiency play an important role. We deliberately set ourselves apart from measurement technology and measurement systems from the testing environment, which pursue a different objective.

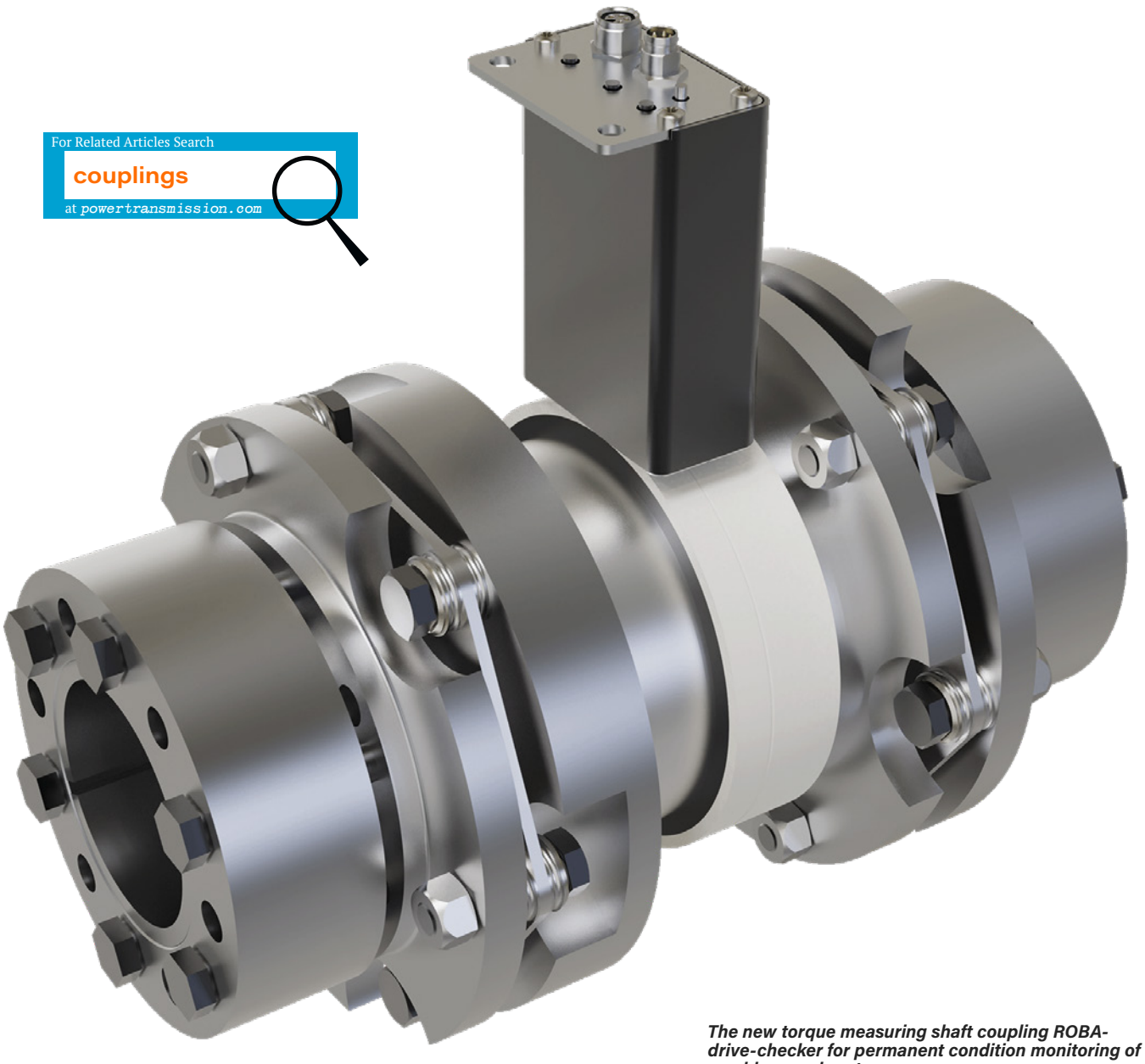
The sensor technology of the smart couplings helps to reduce or completely avoid faults and downtimes. This is because monitoring in the drivetrain makes it possible to detect faults and wear that are creeping up on you at an early stage and then act with foresight. The right wear parts can also be ordered in advance when planning maintenance periods, for example. This reduces the time required for maintenance and thus the overall downtime of the system. Especially changing vibration patterns or torques in unchanging process sequences are ideal signals or indicators. Load conditions that are recorded by the sensors (torque/accelerations) in the drivetrain also enable the operator of the system to carry out the maintenance interval earlier or later if necessary and to plan better. In addition to the service life of the machine, the output increases and the quality of the product can also be improved if necessary.

From Industrial to Robotic Applications

Today, all users want to know about torques in the drivetrain. However, this only works if there is enough space for implementation. This quickly leads to costs again. We are trying to reduce the costs significantly. The focus of development is on the interface. Today, the ROBA-drive-checker is a new component in the proven modular system of the backlash-free disk pack coupling ROBA-DS. The core elements are the Multi-Gateway and the ROBA-drive-checker sleeve. As all connection options of the ROBA-DS steel disk pack coupling are available, this process monitoring system can be easily integrated into many existing applications, including in the field of robotics. Furthermore, a connection to EAS safety clutches is also possible.

In the past, machine maintenance was carried out according to a relatively rigid schedule. Superfluous

For Related Articles Search
couplings
at powertransmission.com



The new torque measuring shaft coupling ROBA-drive-checker for permanent condition monitoring of machines and systems.

maintenance or cleaning was also carried out, simply because it was their turn. Today, changes in torque provide information about the degree of contamination, for example. Maintenance is therefore targeted, only where necessary, planned, and efficient. Maintenance cycles are becoming longer or more individualized, downtimes shorter.

ROBA-DS steel disk couplings for robotic applications.

Single-Source Benefits

As a drive technology specialist, we can evaluate customer applications on a system-open basis. As we cover all common designs (steel disk, elastomer, and metal bellows couplings) with our large portfolio, we can advise customers independently and with a focus on the respective application. But even beyond this—across several machines—the customer needs fewer suppliers overall, as we also have safety brakes and overload clutches in our range. We have the expert knowledge in-house, so we do not have to rely on external know-how. With the new ROBA-drive-checker, this is expressed in concrete terms: the user retains complete control over the data transferred from the sleeve to the Multi-Gateway. External cloud systems or third-party software are not required. The ROBA-drive-checker is a 100 percent development of Mayr Power Transmission. The company supplies the system as a complete package from a single source.

High-speed applications

Based on our tried-and-tested ROBA-DS steel disc coupling, we have developed a weight-optimized version made of aluminium with unchanged power density. This is intended for high-speed applications, for example in the field of test bench technology. We are already looking forward to the official presentation of this new development.

mayr.com

PTE

Master Power Transmission's Automation Transformation with Ready Robotics

A leadership perspective on advanced automation integration

David Regan, Director of Enterprise Sales, Ready Robotics

In the highly competitive gear manufacturing industry, Master Power Transmission (MPT) recognized the need for innovation. To achieve this, MPT partnered with Ready Robotics, undertaking a transformative journey into advanced automation through their Automation Readiness Assessment (ARA).

Ready Robotics and ForgeOS make it possible to automate high mix/low volume processes.

Objective

MPT's objective was clear: to effectively integrate advanced automation into their manufacturing processes, thereby enhancing efficiency, optimizing labor, and promoting sustainable practices.

Solution: Automation Readiness Assessment (ARA)

The ARA, developed by Ready's VP of Manufacturing Technology & Automation Allan Gibson, provides a systematic approach to identifying and scoring potential automation opportunities within a production facility.

The ARA evaluates both traditional and untraditional automation opportunities including how to deploy automation for high-mix operations that previously seemed unattainable. The end goal of the ARA process is to deliver a report and executive team summary that lays out a blueprint for successfully deploying automation that can scale across a facility or multiple facilities.

"We value experts and their capabilities," said Ryan Roberson, President/COO of MPT. "We were confident that Ready Robotics would layout a game plan after witnessing our processes."

Implementation Strategy

The ARA involved a detailed data collection phase, focusing on MPT's technical, financial, and operational aspects.

"Our biggest challenges were setup reduction, automation, and process compression," Roberson noted. "The ARA confirmed some of our ideas and put real numbers to a plan, something we could only roughly speculate before."

For Related Articles Search
robotics
at powertransmission.com

A Q&A with, CEO of Master Power Transmission Michael Cinquemani

Michael Cinquemani, CEO of MPT

Can you elaborate on the specific challenges Master Power Transmission faced prior to implementing the Automation Readiness Assessment (ARA), and how did the ARA help in addressing these challenges?

The key challenge MPT was up against was a genuine lack of awareness regarding where industrial automation could apply. Specifically, in a high-mix/low-volume environment with the majority of our components much larger than we see in typical high-volume/low mix, we don't have the experience to know where existing technology can and has worked well. RR brings a ton of valuable experience to the table, and as industrial automation is their core competency, if

they haven't "seen it all", they certainly have seen more than MPT has seen, and they were able to view the operation through a lens of "been there/done that". During the assessment visit, they weren't only able to identify opportunities, but they were able to quickly cull the projects that would waste time and money based on real experience, allowing them (and us) to focus on the projects that not only were "doable", but also justifiable from a financial perspective.

What were the key factors that led Master Power Transmission to partner with Ready Robotics for their automation transformation, and how did the partnership contribute to achieving MPT's objectives?

Immediately evident, RR is a professional group of automation guys. With that, they are also manufacturing guys who have a better-than-basic understanding of what we do, allowing them to quickly speak in terms with which we were familiar and comfortable. It didn't take long to understand that they are very good at what they do and have done it enough to be a quick and capable resource for MPT. Everything about RR was consistent with MPT's Faster@Master philosophy, from scheduling the initial ARA through the implementation of our first project. For lack of a better term, MPT has experimented with or "dipped its toes" into industrial automation, and the results have been less than stellar, so far. RR stepped in and we are close to wrapping up a project that's been three years in process, and we wouldn't be where we're at today without RR's expertise. Further, MPT will be in a much better position to be successful in our next automation project.

Robot resurrection: The 'Bob Ross' paint cell universal robot.

Discovery of Automation Opportunities

Through the ARA, Ready Robotics identified several key automation projects. This included reviving an underutilized painting robot, named 'Bob Ross', and five new automation projects focusing on machine tending.

"Our experience in deploying automation prior to the ARA was very limited," admitted Roberson. "Small obstacles were huge roadblocks due to our lack of engineering expertise in automation." These initiatives were designed to elevate productivity, reduce lead times, and incorporate digital traceability, essential for gear manufacturers in highly regulated industries such as aerospace.

Results: Enhancing Productivity and Efficiency

The integration of 'Bob Ross' was a highlight, showcasing Ready Robotics' expertise in maximizing underused assets.

Could you discuss the criteria used to identify and prioritize automation opportunities within Master Power Transmission's manufacturing processes, as outlined in the ARA?

Regarding the ARA, the two key points were "Can it be done?" and if so, can we financially justify doing it? The detailed report associated with the assessment identified key metrics such as cost, operations effort, engineering effort, scalability, and value generation, all of which MPT is familiar with. They were able to break complex projects into terms that made it very easy to compare across several alternatives, focusing our go-forward efforts on the projects that would return the best bang for the buck.

In what ways has the integration of advanced automation, including the utilization of "Bob Ross" and other automation projects, impacted Master Power Transmission's productivity, efficiency, and overall operational performance?

While MPT is very early on in our automation roadmap, the ARA and RR have been instrumental in ensuring that we are going to achieve the benefits we expect while providing MPT with the expertise necessary to do more, with automation, in the future. Regarding industrial automation, I believe the measure of success will/can be different for each business, and MPT is positioned to get much more than originally believed by taking advantage of the broad capabilities of RR.

master-pt.com

Ready Robotics' ForgeOS reduces programming time down to minutes.

"We were impressed with the overall ARA process," said Roberson. "What makes Ready's approach unique is the focus on the entire value stream rather than just the automation opportunity. This approach ensures that the automation efforts are going to be focused on the best overall business impact."

The other automation projects, focused on machine tending, showed promising financial justifications. "The implementation team's capability and professionalism have been impressive," Roberson commented.

Strategic Impact and Industry Benchmark

MPT's collaboration with Ready Robotics has established new benchmarks in gear manufacturing automation.

"There is a path to industrial automation for MPT," Roberson reflected. "With Ready Robotics' support, our speed of identification and implementation will continue to improve."

Industry-Wide Implications and Key Takeaways

This case study serves as a valuable example for gear manufacturers contemplating automation. "If other AGMA members are unsure where to begin or don't have the contacts to develop real costs or designs, the ARA is a fantastic first step," advised Roberson.

Resources and Guidance for Gear Manufacturers

Ready Robotics provides extensive resources for companies exploring automation. Their website, LinkedIn, and YouTube channel offer training materials and insights into managing high-mix manufacturing environments.

Conclusion

Master Power Transmission's journey with Ready Robotics demonstrates the transformative power of strategic automation.

"Undergoing this process showed us that there is a path to industrial automation for MPT," concluded Roberson.

For gear manufacturers seeking to remain competitive, this case study offers valuable insights and lessons, showcasing that embracing advanced automation is a strategic necessity in today's evolving market. MPT's experience serves as an inspiring model, illustrating that with the right approach and expert support, transitioning to advanced automation can significantly elevate manufacturing capabilities.

ready-robotics.com

PTE

Fast Shipping of In-stock Products

FREE Shipping - Orders over $49 2-day shipping

FREE Technical Support Located in USA

TOP RATED BY CUSTOMERS

FREE Downloadable Software for many products see website for details

45-day Money-Back Guarantee 45 day

Over 35,000 quality industrial control products at great everyday prices are available on our webstore 24/7/365, and each one comes with the customer service you deserve.

AUTOMATIONDIRECT.com

www.AutomationDirect.com 1-800-633-0405

The #1 Value in Automation

AutomationDirect: much more than just a

AutomationDirect is a non-traditional industrial controls ideas from the consumer world to serve your automatio quality products fast for much less than traditional supp every step of the way. See below . . .

Our campus is located about 45 minutes north of Atlanta, GA, USA. **We're all here** - our sales and technical support teams, purchasing, accounting, and of course our huge warehouses and speedy logistics team.

You want complete product information to make the right purchase decision.

Whether you're deciding on purchasing our products or learning our products after you buy, why jump through hoops or even pay for the information you need?

We have exhaustive documentation all freely available online, including overviews, technical specifications, manuals and 2D and 3D CAD drawings.

We have **over 1,500 videos online** to get you up to speed quickly. We even provide FREE online PLC training to anyone interested in learning about industrial controls.

http://go2adc.com/videos

http://go2adc.com/training

You need quality products at g

For over 25 years, we've been offering a bett by running our direct business efficiently an you. No complex pricing structures or penalt everyday prices on everything from fuses to

Programming software for controller produc can be costly, so we help you out by offering **FREE downloadable software** for all our lat PLC families and C-more HMIs. No license or upgrade fees to deal with**!**

http://go2adc.com/why

You don't want to wait for your

We have fast shipping, and it's FREE if your order is over $49.*

At AutomationDirect, we strive to have what you it. We've invested heavily into infrastructure, inver automation so that we can continue to provide yo products, at great prices, extremely fast!

**Order over $49, and get free shipping with delivery in 2 bu the U.S. (Certain delivery time or shipping cost exceptions Conditions online for complete details. http://go2adc.com*

You insist on getting better service and you want it FREE.

Our technical support team provides superior assistance and has consistently received high ratings from satisfied customers. And it won't cost you a cent!

Before, during, and after any sale, contact us with questions and we're glad to help, *http://go2adc.com/support-ss*

".com"

company using the best
on needs. We deliver
pliers, and support you

great prices.

er value on industrial controls
d passing the savings on to
y for small orders, just low
motors.

tts

est

FREE Downloadable Software for many products see website for details

r order.

need, when you need
ntory, and warehouse
ou with quality

*usiness days (or less) within
may apply; see Terms and
/terms)*

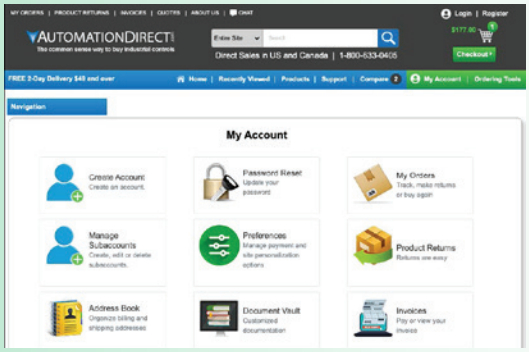
45-day Money-Back Guarantee 45 day

This ".com" is powered by ".awesomepeople"!

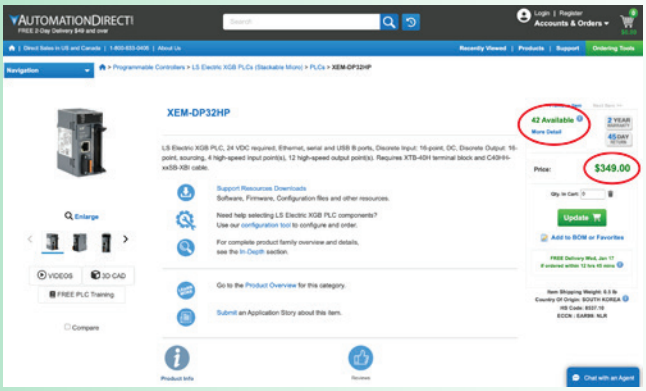
TOP RATED BY CUSTOMERS

Our primary focus has always been customer service — practical products, great prices, fast delivery, and helpful assistance. But the intangible value of customer service is something that cannot be faked, automated or glossed over.

Our team members here at AutomationDirect approach every day with one goal in mind - serve the customer. If the answer to any decision is "Yes, this is good for our customers", then we do it, whether personally or via self-serve features on our site.



Easy access to account and order history, online returns



Upfront pricing and realtime stock availability

You want to be confident in our products and our commitment to you.

We stand behind our products and guarantee your satisfaction.

We want you to be pleased with every order. That's why we offer a 45-day money-back guarantee on almost every stock product we sell. (See Terms and Conditions online for exclusions.)

echnical Support Located in USA

Check us out at: www.automationdirect.com

AUTOMATIONDIRECT.com

The best values in the world . . .

We've shopped around to bring you the most practical, reliable industrial control products at the best prices!!

BRIAN in CLEVELAND, TN:
"I love having a single website that I can use for selecting and purchasing everything I need for our industrial automation projects. With fast shipping times, an active support forum, and competitive prices, there's nothing else that compares. Thanks!"

CODY in MOORESVILLE, NC:
"Best phone support I've gotten from a supplier yet, answers the phone quickly and has a very knowledgeable staff."

DAVE IN MITCHELL, SD:
"In 10 years of using the company products and services I've only had a few returns. The products are reliable and the customer service has always been second to none. I plan to continue using the company into the future."

JOHNNY IN NEW CANEY, TX:
"Excellent company. Use it regularly and highly recommend it to others."

BEN IN PAHRUMP, NV:
"We use AutomationDirect as a standard supplier for many of our UL508 control panel components, and have never had a single issue! Automation Direct has an incredible stock of inventory and product selections, and the two day shipping gets us the parts we need right on time!"

Mark in AYLMER, ON:
"We have been buying from Automation Direct for quite a few years now and we have been really happy with the service and range of products available and the prices are usually as good or better than elsewhere."

Daniel in ALLIANCE, OH:
"They are the best game in town for industrial PLCs"

Plus more products launching weekly!

A quality product line, with FREE
#1 rated technical support and quick shipping!
Call 1-800-633-0405 or visit us at:
www.AutomationDirect.com

Needle of the Midday

FCMD North America Keeps Ski Resort Running Efficiently

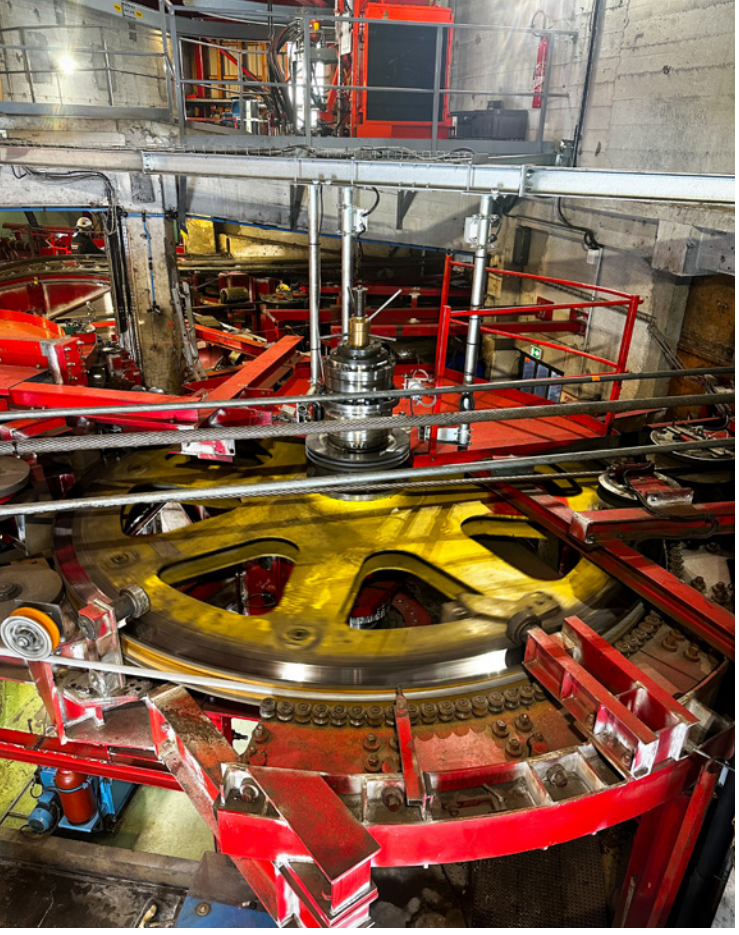
Matthew Jaster, Senior Editor

Half a million global visitors visit Aiguille du Midi as an access point for skiing in the winter and hiking, rock climbing and paragliding in the spring, summer, and autumn seasons. The mountain—part of the French Alps—boasts the current title of employing "the world's highest vertical ascent cable car." This unique transportation takes passengers from 3,396 to 12,605 ft. above the clouds. The planetary gearboxes needed for the cable car operation are provided by CMD Gears.

The Aiguille du Midi cable car connects the center of Chamonix, France up to the summit. It is a two-stage journey starting at 1,035 m altitude up to 2,317 m at the Plan de l'Aiguille. A second stage, without any support pillars, traverses Les Pelerins glacier before rising the North Face of the Aiguille du Midi at the top station at 3,778 m.

"The ski lift was originally built in the 1950s," said Clement Ravache, sales engineer, CMD Gears, France. "Then, in the early 1990s as a modernization project, the Mont Blanc Company, responsible for the lift, started working with engineering companies from within the region and thanks to our expertise and long history with reducers, CMD Gears was issued the contract to supply three planetary gearboxes."

For Related Articles Search
planetary gearbox
at powertransmission.com



CMD Gears has been supplying planetary gearboxes for the Aiguille du Midi ski lift since the early 1990s.

Maintaining and replacing planetary gearboxes on a ski lift in Europe comes with a unique set of challenges.

Installation at 12,605 ft.

Fast-forward 30+ years and that same company reached out to CMD to supply one more planetary gearbox. The plan was simple: Operate three reducers and have an additional reducer on-hand as a spare part, Ravache added.

Gearbox installation for any application has its own unique set of challenges, but how about handling equipment of this size and scope on a mountain?

"Some of the challenges involved with the job were first, the altitude at which the job had to be performed and the gearbox installed," said Ravache. "Indeed, the design of the lift was made so all three gearboxes would operate from the middle section—thus at 2,317 m altitude. For security reasons, the lift was designed so that one gearbox would drive the first stage and one for the second with a back-up right beside it."

Another challenge was the time given to swap gearboxes.

"Keep in mind that the summit is very popular and attracts tourist year long. Thus, giving little time for maintenance services. The service team was given only three days to do their job before inspection and testing was conducted by a third party," said Victor Manoury, sales engineer at FCMD North America, representing CMD Gears in North America.

"The last challenge goes without saying," said Ravache. "The new gearbox has a zero-failure allowance. Having people stuck in the middle of the lift would be a disaster."

Since the gearboxes were originally supplied by CMD Gears, the company has been involved with various maintenance operations over the years.

"Mont Blanc Company naturally called us back to build its brand-new planetary reducer," Manoury said. "The new gearbox comes with newer technology and is made of better materials."

While maintenance operations have been done directly on site over the last couple of years, now that the Mount Blanc Company has a spare part this permits greater flexibility. "This allows them to send back their reducer to our workshop in Cambrai, France and have us perform our usual gearbox inspection by fully inspecting each component inside," Ravache said.

The field engineers' experience in areas like cement and mining—where installations and maintenance take place in both extremely hot and cold environments—helped the team prepare for the ski lift upgrade.

"Our field servicing team is quite used to working in these types of conditions," Manoury said. "Field servicing is one of the three solutions we provide to our clients. We have vast experience in gearbox manufacturing, on-site services, and repairs."

Investing in New Technology

CMD Gears is constantly investing in advanced machines to be used throughout its various projects. In 2024, the company will install a brand-new vertical turning machine to increase capacity at its Fourchambault, France facility.

A year ago, they made a large investment for a 6.5 m diameter gear grinding machine. This gear grinding machine

The new replacement gearbox came with newer technology and better materials than previous versions.

FCMD's experience in areas like cement and mining—where installations and maintenance take place in both extremely hot and cold environments—helped the team prepare for the ski lift upgrade.

is installed and fully running at the company's Cambrai, France workshop.

Closer to home, FCMD North America is currently supplying the whole grind mill drive system (gearboxes, ring gear, pinion, and auxiliary drive) for large copper and gold mining projects.

An Engineering Perspective

The station of the Aiguille du Midi has several terraces where visitors can take in the spectacular views of the French, Swiss and Italian Alps.

On a clear day, it is possible to see the Matterhorn (4,478 m), the Monte Rosa (4,634 m) the Grand Combin (4,314 m), and the summit of Mont Blanc (4,810 m). Often, during the summer season, it is possible to spot climbers on their way up this face towards the summit of the Aiguille du Midi. (*chamonix.net/english/leisure/sightseeing/aiguille-du-midi*)

The name Aiguille du Midi translates literally to "Needle of the Midday." The mountain lies to the south-east of Chamonix and when viewed from the front of the church it indicates that it is noon when the sun passes over its summit.

The engineering team is extremely proud to move half a million visitors to and from the mountain safely throughout the year.

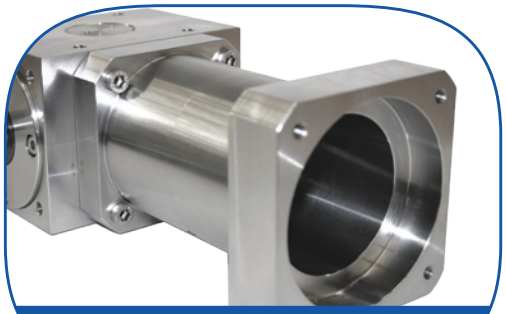
"We've had ring gears, gearboxes and pinions running for more than 25 to 30+ years in some applications without any issues or problems," Manoury said. "This is a testament to the knowledge of our service engineers as well as our long-term European manufacturing and quality expertise."

fcmdna.com

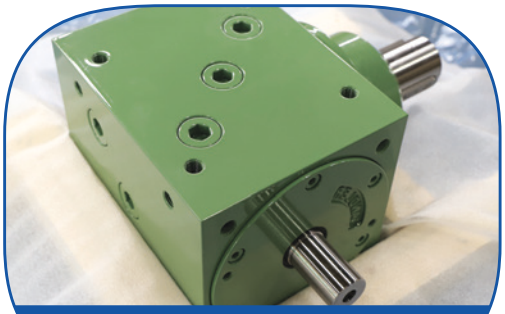
PTE

When off the shelf just won't do.

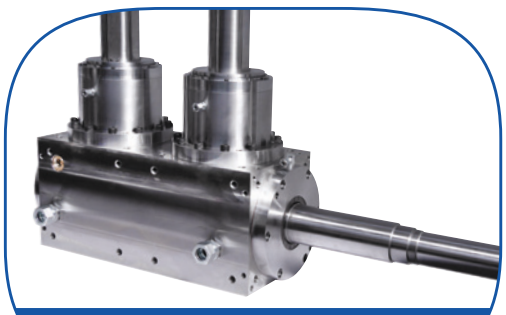
With our enormous variety of standard components and custom machining capabilities, a custom-designed and manufactured gearbox for specific applications is something we do all the time.



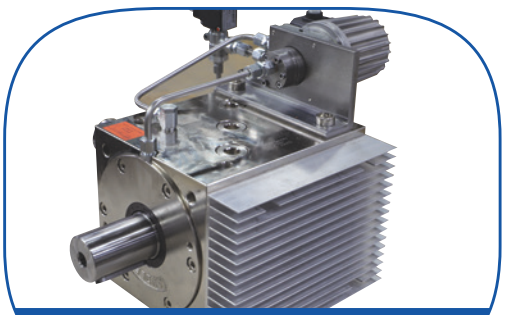
Custom Flanges



Custom Paint



Complete Redesigns



Gearbox Cooling

DIEQUA Corporation

180 Covington Drive
Bloomingdale, IL 60108 USA

630-980-1133

www.diequa.com

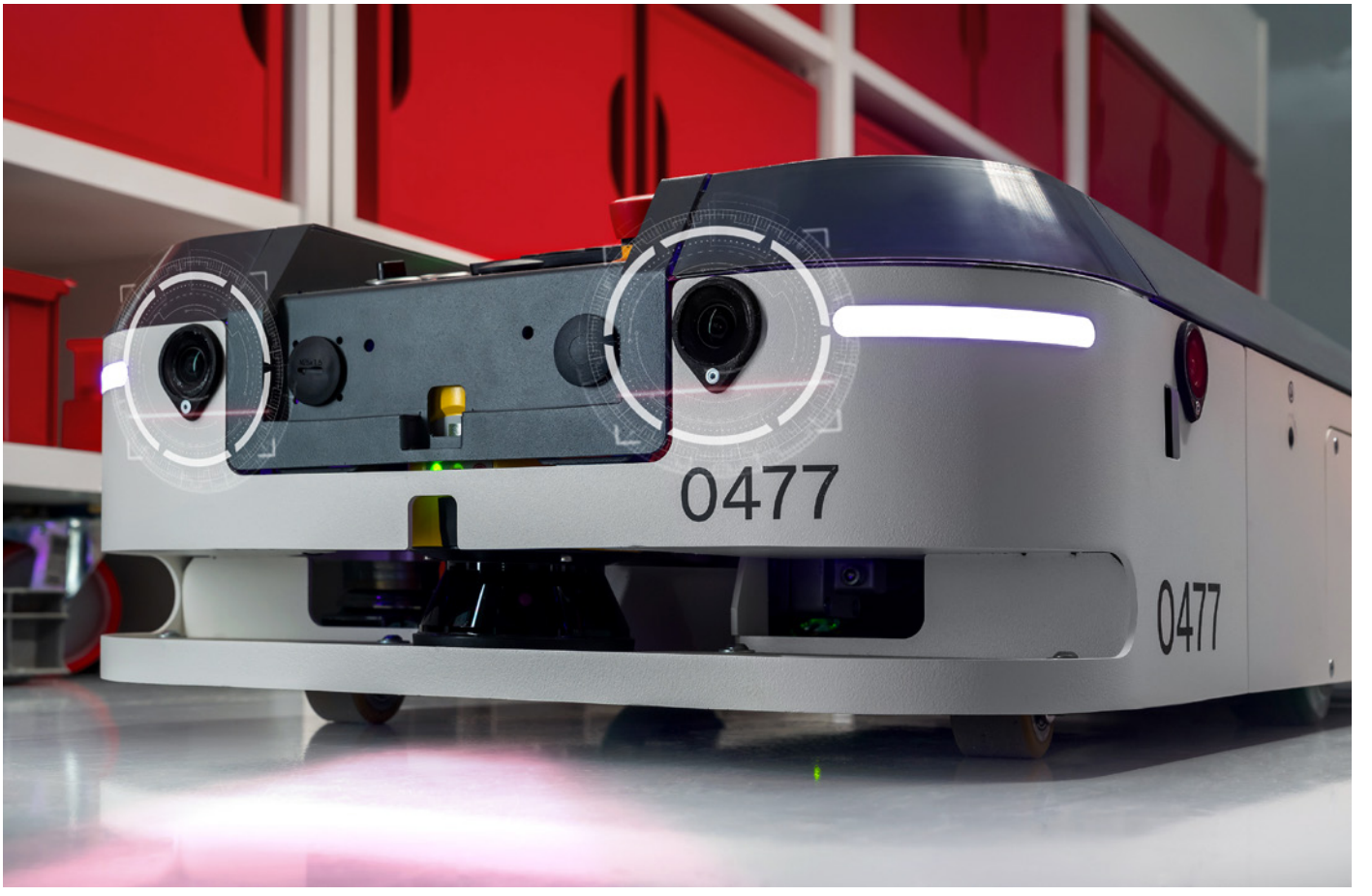
Motion Control and Power Transmission Drive Components

The Flexible Factory

See the shift in production lines and technology during Automate 2024

Matthew Jaster, Senior Editor

Automate 2024 (Chicago) offers comprehensive automation education and new developments in robotics, vision, AI, motion control and other technologies. Automate delivers the latest innovations in manufacturing automation technology from more than 800 exhibitors. If the robotic and automation highlights aren't enough, the show also hints at the evolution of AI, IIoT, e-Mobility, condition monitoring and intuitive software. This article previews the show floor topics reshaping manufacturing for the foreseeable future.



From mobile robots to cobots and beyond, AI is giving robots unprecedented levels of speed, accuracy, and payload carrying ability, enabling them to take on more tasks in settings like flexible factories, warehouses, logistics centers and laboratories.

Expanding Capabilities of AI

Marc Segura, president, ABB Robotics Division said accelerating progress in AI is redefining what is possible with industrial robotics. AI is enhancing everything from robots' ability to grip, pick and place as well as their ability to map and navigate through dynamic environments. From mobile robots to cobots and beyond, AI is giving robots unprecedented levels of speed, accuracy, and payload carrying ability, enabling them to take on more tasks in settings like flexible factories, warehouses, logistics centers and laboratories.

"AI-enabled mobile robots can transform sectors like discrete manufacturing, logistics and laboratories," said Segura. "Robots equipped with ABB's new Visual Simultaneous Localization and Mapping (Visual SLAM) technology, for example, have advanced mapping and navigation skills, granting new levels of autonomy, while greatly reducing the infrastructure needed by previous generations of guided robots. This paves the way for a shift from linear production lines to dynamic networks, creating significant efficiencies and taking on more dull, dirty, and dangerous tasks, to enable workers to take up more rewarding jobs."

IT/OT Integration

The future of manufacturing is intricately linked to IT/OT integration as data will underpin innovation and efficiency, said Anders Billesø Beck, vice president of innovation and strategy at Universal Robots. "Research shows that the manufacturing industry has been at the forefront of adopting cloud-based software services and we are already seeing some customers use these to enhance quality, cost efficiency, and predictability. That makes me confident that 2024 will see the growth of data-driven logistics and manufacturing systems," Beck said.

Many still have an outdated view of the cloud merely being a data collector and backup function, as we know from our private lives. But the real potential and power doesn't lie in storing data or even in linking machines. The real transformative leap comes when cloud-based software services connect humans and machines and thus help manufacturers simplify complex processes and make smarter decisions.

The benefits of this digital evolution are significant. Remote access to manufacturing data enables quick responses to issues and continuous automation improvement. With dynamic systems now essential, trusted cloud technologies offer the latest in security and state-of-the-art services. IIoT companies highlight this progression, promising improved efficiency, and reduced downtime through Overall Equipment Effectiveness (OEE) visualization and predictive maintenance.

Manufacturers stand to gain from these advancements, achieving higher quality, reduced downtime, better predictability, and cost optimization. This transition is a strategic necessity, supporting the shift towards high-volume, high-mix production, resilient supply chains, competitive data utilization, and sustainability goals.

Evolution of Cobots

The Fanuc CRX-25iA cobot offers an enhanced 30 kg payload and 1,889 mm reach for case palletizing. Guided by a 3DV/200 iRVision sensor mounted to the arm, the CRX-25iA will palletize boxes to nearly 7' high. In addition, the CRX-25iA can be mounted to a mobile cart to showcase its flexibility. The robot can be easily repositioned by hand and uses vision to automatically adjust to its new location and continue working accurately. Fanuc's entire series of CRX collaborative robots are reliable, flexible and can run for eight years without maintenance.

Specifically designed for palletizing tasks, the robust HC30PL collaborative robot from Yaskawa Motoman—with plug and play capability—facilitates safe, efficient fenceless production in demanding environments. Ideal for medium-volume lines, this cobot offers hand-guided programming for fast deployment on demand, and it features a 1,700 mm maximum reach, a 30 kg payload capacity, an easy-to-clean surface, and NSF H1 certified food-grade grease as standard. Meeting established safety standards, the HC30PL supplies four modes of collaborative operation and can easily shift between collaborative speed in PFL mode or full speed in industrial mode (based on risk assessment and process requirements) to accommodate fluctuating demands.

The Universal Robot UR30 was presented during iRex 2023 in Tokyo, Japan.

Universal Robots UR30 is the second in Universal Robot's new series of innovative, next generation cobots and is built on the same architecture as the UR20.

The UR30 is ideal for several applications, including machine tending, material handling and high torque screw driving. For machine tending, the high payload brings new possibilities as it allows the cobot to use multiple grippers at the same time. This means it can remove finished parts and load more material in one single pass, shortening changeover times and maximizing productivity.

"As industries evolve, the UR30 not only meets but anticipates shifting demands, enabling businesses to adapt and respond to changing needs effectively. As we continue to innovate, the UR30 is another step in UR's journey in pushing the boundaries of what is possible in the world of automation," said Kim Povlsen, president, Universal Robots.

Where is this technology going in the next five to ten years? This will be a question posed to several exhibitors on the trade show floor this May.

Augmented Reality Software

Employing the power of smartphones and Augmented Reality (AR), Kuka has launched its new *Kuka.MixedReality* software that allows users to visualize the environment of robot cells live on their smartphones to support fast, safe, and intuitive robot startups. The free mobile app displays tools and interference geometries for early detection of potential hazards that can then be eliminated before a robot even starts to work.

AR enables such intuitive robot startup assistance capability, connecting the real and virtual worlds to enrich the environment of robotic cells with clear, uncomplicated digital information. By quickly detecting and correcting errors, facilities accelerate installation and boost safety.

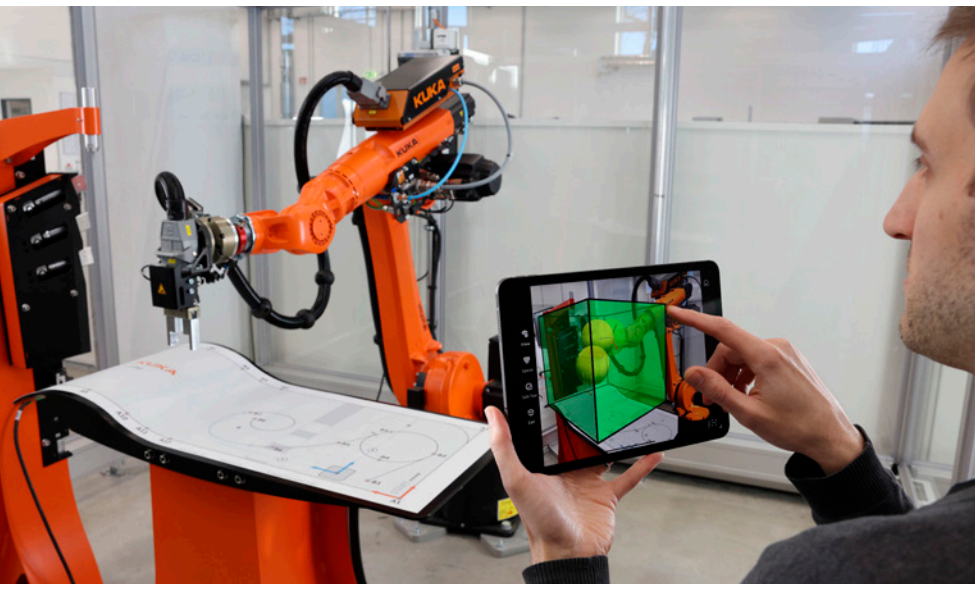
For example, the software will simulate robot motion along with a virtual gripper and detect any potential collisions that arise in the AR environment. These are then resolved at an early stage in the real environment so that neither the robot nor the gripper is damaged.

"Augmented or mixed reality is a future-oriented topic that also offers promising opportunities in robotics," said Roland Ritter, portfolio manager simulation at Kuka. "*Kuka.MixedReality* makes robot installation more user friendly and safe. This benefits customers at all levels of experience in the field of automation."

The *Kuka.MixedReality* Assistant app graphically displays all relevant variables directly for the robot in real time, including Cartesian or violated monitoring spaces, safety-oriented tools, and tool spheres. Users can also view the corresponding configuration parameters of the spaces or tools.

Kuka.MixedReality is easy to set up and operate. Users simply install the *Kuka.MixedReality* Assistant on their smartphone or tablet via the Apple App Store or Google Play Store. All relevant information about the robot is transmitted directly to the mobile end device via WLAN through a router or access point—not a Kuka product—and displays visually on the mobile device. AR headsets or additional hardware are not required, and a *Kuka.MixedReality* safe technology package installs in the robot controller as a data source, along with one of the *Kuka.SafeOperation* technology packages to use with the safe functions.

KUKA.MixedReality ***supports the commissioning of your robot quickly, safely and vividly.***



Monitoring Robotics in Real-Time

Automotive supplier Booster Precision Components GmbH saves time by efficiently planning maintenance work and transferring diagnostic files. The journey from the decision for *Kuka iiQoT* to a transparent overview of the entire robot fleet took a mere few days.

The implementation of *Kuka iiQoT* in a brownfield was quick and easy. On average, we needed about ten minutes per robot. "Now, through networking, we have the assurance that the displayed information is always up to date," says Tobias Sauer, head of automation at Booster Precision Components. The *Kuka iiQoT* dashboard bundles all important information transparently and clearly. This way, the robot fleet can be monitored from its location in Schwanewede, Germany—regardless of the robots' locations worldwide.

"With *Kuka iiQoT*, Kuka robots become smart robots. Thanks to the clear presentation of the robot fleet, notifications in the event of a fault, as well as status monitoring, our customers gain greater transparency and efficiency," explains Christian Büchle, platform product manager for Data-Driven Services at Kuka. Through intelligent data collection in the secure Microsoft cloud, customers can minimize machine downtime in their production operations

and maximize operating time. For example, the necessary maintenance measures for the robots are transparently displayed in *Kuka iiQoT*, allowing harmonization for the entire robot fleet. Several *Kuka iiQoT* functions contribute to quick troubleshooting, such as condition monitoring, which records trends and irregularities. The customer-specific messages support troubleshooting by reporting critical events and fault hotspots for the robot.

Energy Efficiency in Motors and Drives

Sustainability is the name of the game yet many organizations are falling short of original decarbonizing targets. This by no means suggests sustainability is off the table—merely that companies need to reevaluate internal improvements, provide additional electric motor/drive options, and consider adjusting decarbonizing goals in a practical, realistic manner with an appropriate timetable. Industrial automation providers such as Fanuc, ABB, and Yaskawa America can provide a blueprint to help smaller organizations embrace energy efficient components and shop floors.

Components for the EV Sector

IKO International recently discussed new EV investments in an automated production infrastructure. There are aspects of EV manufacturing in which specifying an appropriate motion component requires particularly careful consideration. That's because the heart of the EV—the lithium-ion (Li-ion) battery—poses safety and performance risks that you must keep in mind when selecting motion components. To minimize these risks, it's important to partner with a supplier that can help you select an appropriate device and offer modification options to meet the distinct requirements of Li-ion battery manufacturing processes.

Linear guides can function reliably in challenging environments—such as Li-ion battery manufacturing—with careful selection, protection, and proper lubrication.

Although copper is commonly used in Li-ion batteries, its hard-to-detect particles can contaminate the electrode and cause dangerous internal short circuits. Components used in Li-ion battery production should be free of copper-based substances and must not generate dust or dirt. In addition, moisture and humidity hinder Li-ion battery lifetime and performance.

Linear guides can function reliably in challenging environments—such as Li-ion battery manufacturing—with careful selection, protection, and proper lubrication. IKO has extensive expertise and a wide range of protective accessories available to create a custom product that will perform trouble-free.

Changing Markets for Robotics and Automation

In 2023, A3 reported the strongest demand for robots from non-automotive companies came from the metal industry, followed by semiconductor, electronics/photonics, food and consumer goods, life sciences, pharmaceutical and biomedical, plastics and rubber, and others.

While each of these industries showed an overall decline compared to 2022, the last three months of the year saw higher sales in automotive (both OEM and components), metals, semiconductor/electronics/photonics, plastics and rubbers, metals and the All Other Industries category, resulting in an increase of 20 percent over the previous quarter (Q3 2023). The All Other Industries category includes companies in areas such as construction, hospitality and agriculture, typically newer to robotics.

"While robotic sales were down over the year, 2023 ended with both an increase over the previous quarter and a nearly equal number of sales from automotive and non-automotive companies," said Jeff Burnstein, president of A3. "Both are promising signs that more industries are becoming increasingly comfortable with automation overall. While we expect to see automotive orders rise again, there's little doubt that orders will increase from all non-automotive industries as they recognize how robots can help them overcome their unique challenges."

The potential offered by AI-enabled robotics is influencing sectors far beyond manufacturing, according to Segura at ABB Robotics Division. In 2024, these technologies are expected to bring substantial efficiency improvements to more dynamic environments, such as healthcare and life sciences, as well as retail. Another example is the construction industry, where AI-powered robotics can make a material contribution to boosting productivity, enhancing safety and sustainable construction practices while spurring growth.

"The construction industry is a great example of a sector where AI-powered robots will prove transformative, delivering real value by addressing many of the issues facing the industry today, including worker shortages, safety issues and stagnant productivity," said Segura. "Abilities such as enhanced recognition and decision-making offered by AI, coupled with advances in collaborative robots enable safe deployment alongside workers," Segura said. "These advances also enable robots to perform key tasks such as bricklaying, modular assembly and 3D printing with greater precision and speed, all while contributing to more sustainable construction by lowering emissions, such as concrete mixing on site, to reducing the need to transport materials across far distances with on-site assembly."

Automate 2024 takes place May 6–9, 2024 at McCormick Place in Chicago.

automateshow.org

PTE

For Related Articles Search
automation
at *powertransmission.com*

MIDWEST BUILT

PRECISION COUPLINGS

SENSOR TECHNOLOGY

INDUSTRIAL COUPLINGS

Our new U.S.-based production facility integrates the best of both worlds – the pride of American manufacturing and the precision of German technology.

With advanced equipment and cutting edge processes, our factory ensures incomparable efficiency and quick delivery times.

Join us in our commitment to excellence and benefit from our expertise. **Contact us now to be a part of our success story.**

R+W Coupling Technology
845 W Hawthorne Lane
West Chicago, IL 60185

+1 630 521 9911
info@rw-america.com
www.rw-america.com

R+W®
A POPPE + POTTHOFF COMPANY

Flexibility in Gear Design

Load collectives in the *FVA -Workbench* expand design capabilities

Benjamin Abert, FVA GmbH

Conventional gearbox designs based on nominal power and speed are generally not sufficient to meet the diverse requirements of modern applications, such as resource efficiency at high power density, high efficiency, and long service life. On the contrary, various operating states must be isolated and the combinations between them must be considered. This is done using load spectra.

Up to this point, so-called "scaled load spectra" were used for the consideration of load spectra in the *FVA-Workbench* (*powertransmission.com/blogs/1-revolutions/post/9006-fva-presents-transmission-design-considerations*).

These load spectra consist of scaling factors for speed and torque in the power flow. Aside from constant loads, all remaining loads in the system were scaled with the power flow.

With the current version of the *FVA-Workbench*, this feature has been expanded to include "flexible load spectra." This makes it possible to create any combination of loads and switched gears with the associated time percentages in an intuitive editor (see Figure 1).

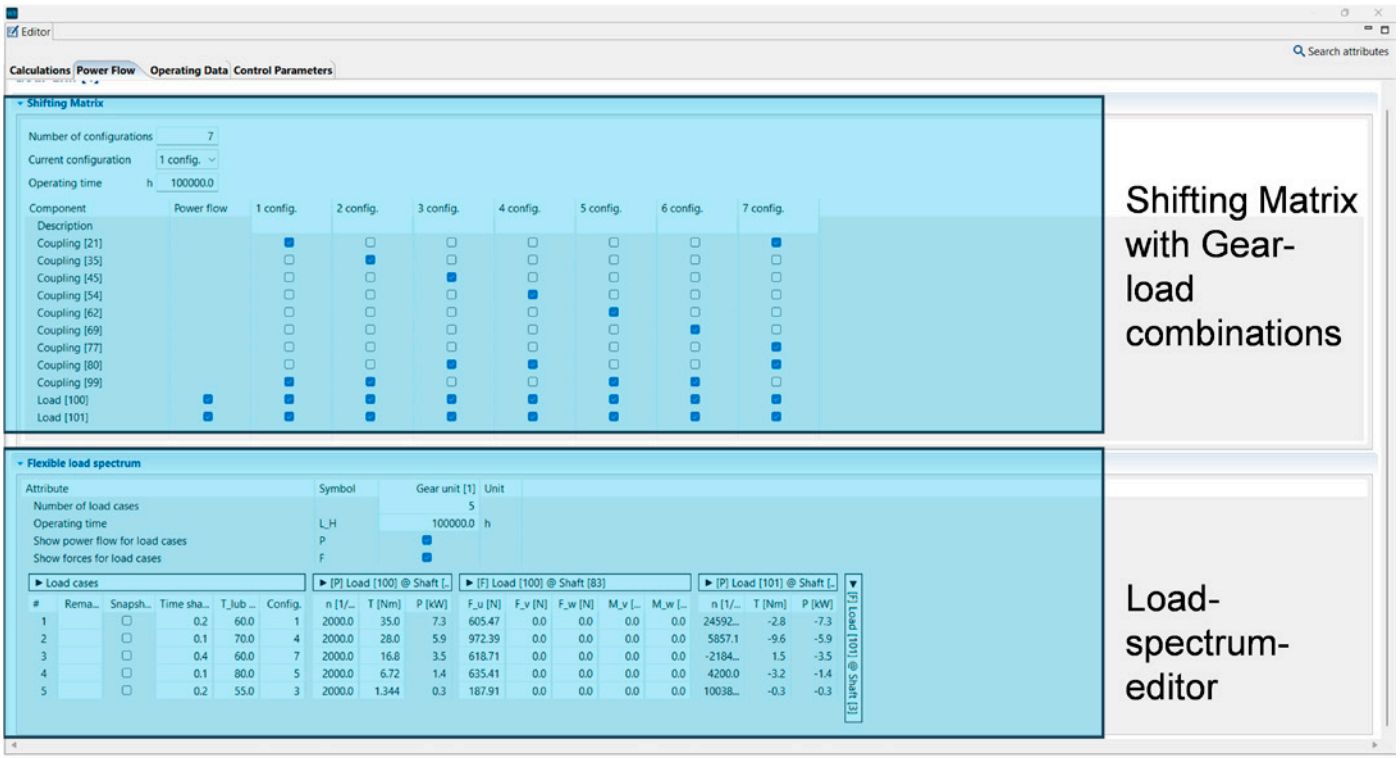


Figure 1—Shifting matrix with gear-loaded combinations and load collective editor.

A separate system calculation is performed for each of these load cases, followed by an additional accumulation of the load cases and their respective time percentages. This means that the user can subsequently evaluate the effects of the various operating states separately as well as the result of the entire calculation in *FVA-Workbench* reports.

Example Application: Rolling Mill Gearbox

The benefits can already be observed in the simple drivetrain of a rolling mill, the schematic of which is shown in Figure 2. The key data for the design originates from the FVA 131 research project.

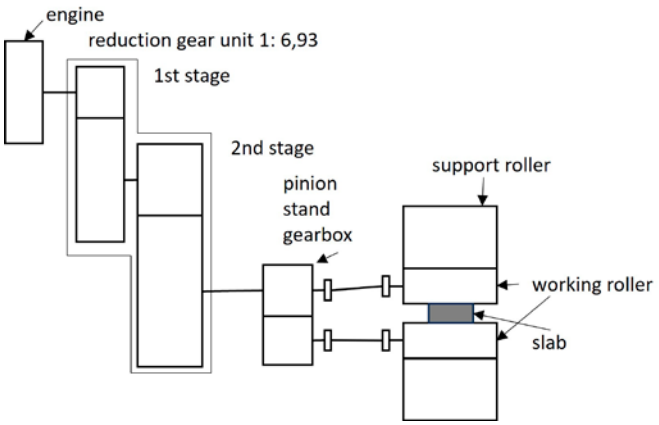


Figure 2—Drivetrain of a rolling mill.

Two important phenomena can occur during the rolling process: normal tapping or tapping with so-called chatter vibrations (see FVA 131). Here, we are only concerned with normal tapping; however, the process for consideration of chatter vibrations is similar. In greatly simplified terms, normal tapping consists of three operating states which are repeated every eight seconds:

- Start of tapping
- Rolling process
- Idle

Figure 3 shows the profile of the normalized torque over time.

With the *FVA-Workbench*, these single-parameter as well as multi-parameter (i.e., with additional consideration of speed, external forces, etc.) time histories can easily be converted into load spectra for the system calculation. Figure 4 shows the prepared load spectrum for normal tapping in the flexible load spectrum editor.

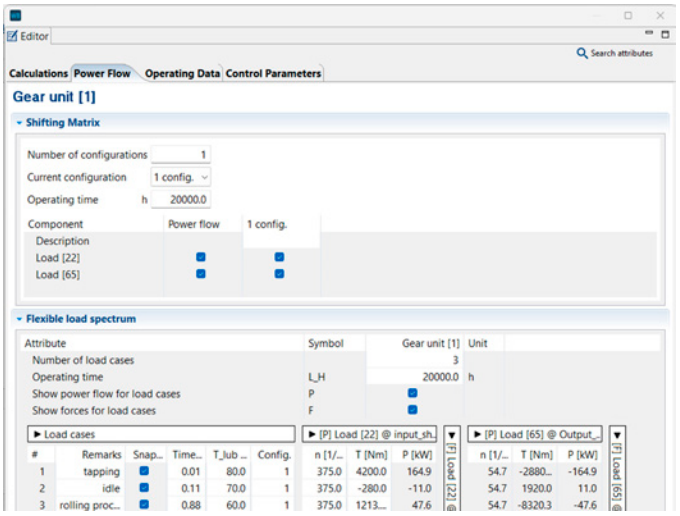
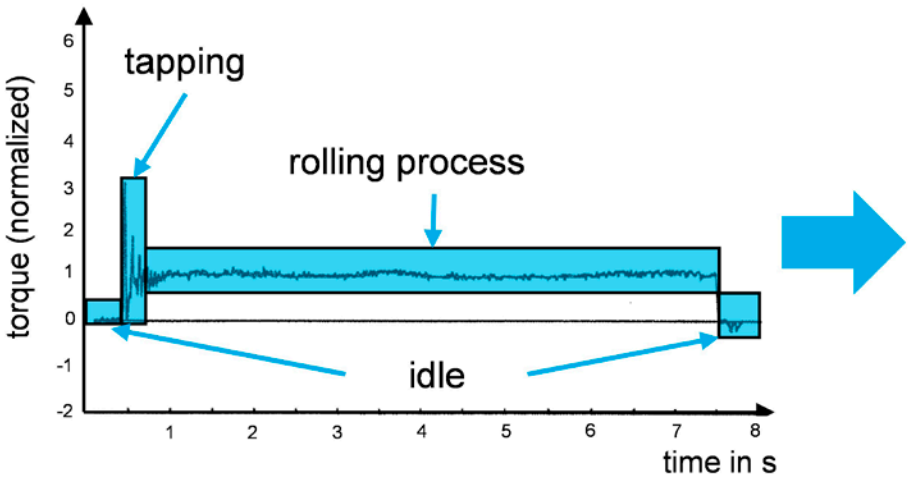


Figure 4—Flexible Load Collective Editor.




```
# Walzwerk_normaler_Anstich.ZVL
# Erstellt am: 16.05.11  um: 09:30:42  von: 100
#     -2  0.000000E+00
#      4      2
#      2      2
# 'Wellendrehzahl',
# 'Wellendrehmoment',
0.000000000E+00 3.750000E+02 0.000000E+00
0.100000000E+00 3.750000E+02 0.000000E+00
0.200000000E+00 3.750000E+02 0.000000E+00
0.300000000E+00 3.750000E+02 0.000000E+00
0.400000000E+00 3.750000E+02 0.000000E+00
0.500000000E+00 3.700000E+02 3.000000E+00
0.600000000E+00 3.750000E+02 0.500000E+00
0.700000000E+00 3.750000E+02 0.500000E+00
0.800000000E+00 3.750000E+02 1.000000E+00
0.900000000E+00 3.750000E+02 0.900000E+00
1.000000000E+00 3.750000E+02 1.000000E+00
1.100000000E+00 3.750000E+02 1.000000E+00
1.200000000E+00 3.750000E+02 1.000000E+00
1.300000000E+00 3.750000E+02 1.000000E+00
1.400000000E+00 3.750000E+02 1.000000E+00
1.500000000E+00 3.750000E+02 1.000000E+00
1.600000000E+00 3.750000E+02 1.000000E+00
1.700000000E+00 3.750000E+02 1.000000E+00
1.800000000E+00 3.750000E+02 1.000000E+00
1.900000000E+00 3.750000E+02 1.000000E+00
2.000000000E+00 3.750000E+02 1.000000E+00
3.000000000E+00 3.750000E+02 1.000000E+00
4.000000000E+00 3.750000E+02 1.000000E+00
5.000000000E+00 3.750000E+02 1.000000E+00
6.000000000E+00 3.750000E+02 1.000000E+00
7.000000000E+00 3.750000E+02 1.000000E+00
7.100000000E+00 3.750000E+02 1.000000E+00
7.200000000E+00 3.750000E+02 1.000000E+00
7.300000000E+00 3.750000E+02 1.000000E+00
7.400000000E+00 3.750000E+02 1.000000E+00
7.500000000E+00 3.750000E+02 1.000000E+00
7.600000000E+00 3.750000E+02 0.000000E+00
7.700000000E+00 3.750000E+02 -0.200000E+00
7.800000000E+00 3.750000E+02 -0.200000E+00
7.900000000E+00 3.750000E+02 0.000000E+00
8.000000000E+00 3.750000E+02 0.000000E+00
```

Figure 3—Profile of the normalized torque.

In the next step, the calculations can be performed using the specified load spectrum.

Available Calculations

In *FVA-Workbench 9*, load spectra (both scaled and flexible) can be considered in the following calculations:

- ISO 6336 2006 and 2019 for cylindrical gears
- Gear excitation according to FVA 338 I for cylindrical gears
- ISO 10300 2014 for bevel gears
- Rolling bearing calculations
- 2012 FKM Guideline for shaft notches
- Local damage accumulation for bevel gears

If desired, snapshots can be created for each load case with all associated results for reporting. This makes it possible to evaluate the individual load cases in the flexible load spectrum in isolation with all the other available calculation methods in the *FVA-Workbench*. This enables users to optimize gearboxes for the entire load spectrum as well as for the individual spectrum stages.

Results Output

In principle, the results are output in a similar manner to scaled load spectra (*powertransmission.com/blogs/1-revolutions/post/9006-fva-presents-transmission-design-considerations*). The key difference, however, is that individual reports are also available for each load case in addition to the report for all accumulated load cases (see Figure 5).

Conclusion

The new flexible load spectrum feature significantly expands the range of calculation and evaluation options in the *FVA-Workbench*. The key innovations are:

- Individual forces and bending moments can be specified separately for each load case
- The oil temperature can be varied for each load case
- A report can be created for each individual load case

The benefits of the scaled load spectrum are also still available:

- Specification of torque and speed for each load case
- Constant individual forces and bending torques for all load cases
- Switchable loads
- A report with the accumulated results of all load cases
- Can be controlled via *FVA-Workbench* scripting.

One final benefit of the scaled load spectrum is that it is possible to interpolate between the load cases, enabling the calculation of extensive load spectra with a high level of computational performance.

fva-service.de

PTE

Editor's Note: Read about the latest *FVA-Workbench* improvements on page 10.

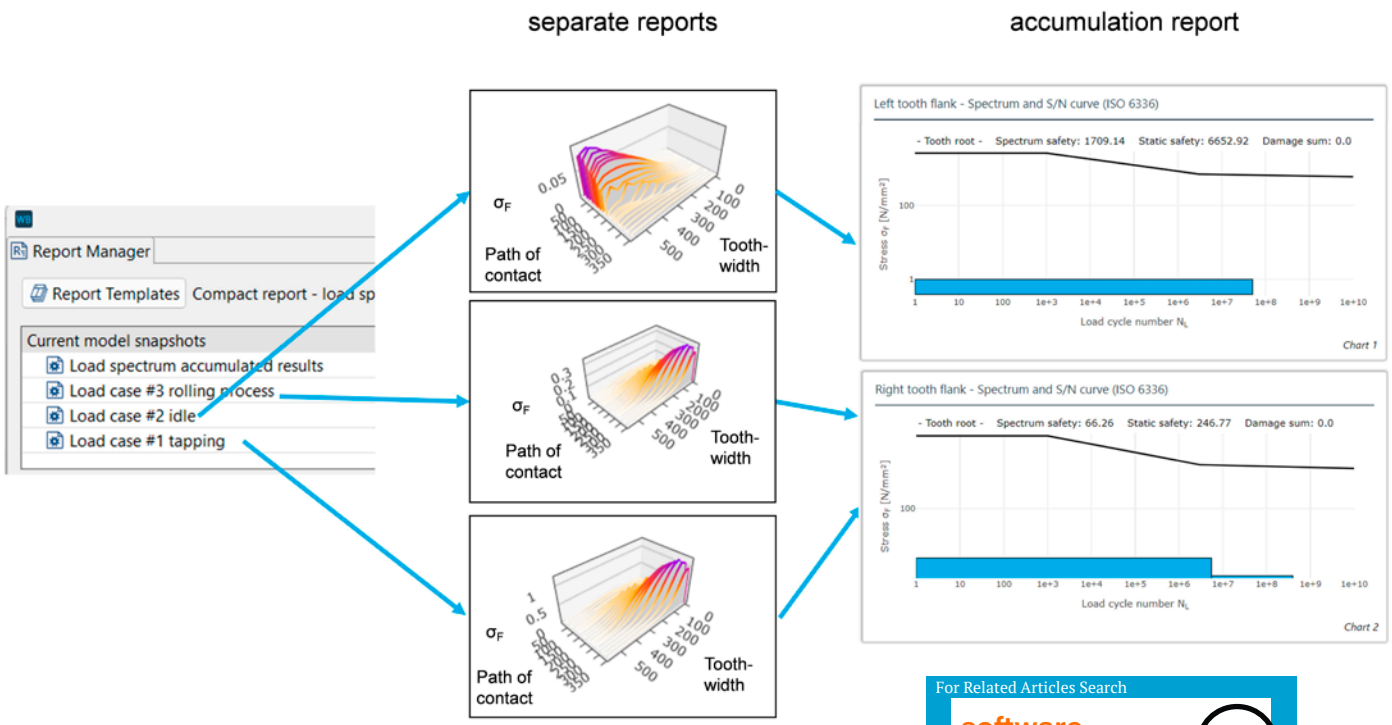


Figure 5—Individual reports and accumulated reports in the result output.

Use of Gear Reliability Data in a Cloud-Based Gearbox Digital Twin Using Telematics Data

Barry James, Louis Long, and Alberto Satine Gioiosa, Hexagon

Defining the Digital Twin

In recent years, few terms in engineering have been given as much airtime as *digital twin*, however, it is often applied in so many different contexts that its interpretation has become extremely confused. The concept of a digital twin was described in 2001 in a presentation by Michael Grieves, being described as a "conceptual idea for PLM [Product Lifecycle Management]" (Ref. 1). In this, digital information would be a "twin" of the physical system, would be embedded within the physical system itself and be linked with that physical system through its entire lifecycle. Grieves expanded on the idea over subsequent years and by studying work by the same, originating author, it can be seen how the different interpretations of the term *digital twin* have arisen.

In 2016 (Ref. 1), Grieves expanded on the definitions, confirming that the digital twin covers all aspects of the product lifecycle, but with different purposes. For example, the digital twin prototype (DTP) covers the design phase, when the physical product does not actually exist. Following from this, the digital twin instance (DTI) is created as a digital representation of a specific physical product, to be linked to that physical product through its entire life. Interestingly, he goes on to talk about digital twin aggregates (DTAs), where data from multiple DTIs is aggregated within what he calls a digital twin environment (DTE).

It is interesting to note that, using this definition, the digital twin prototype (DTP) aligns pretty well with another commonly used term, the *design twin*. Within this context, the DTP/design twin is clearly a computer simulation of the engineered system for use during the design phase. The author finds this curious since this is essentially a computer-aided engineering (CAE) model, provided to and used by industry for well over 30 years and promoted within the context of concurrent engineering, a theme that rose to prominence in the late 1980s. Whilst CAE models of many different systems exist, and may contribute to various Digital Twins, this is not the focus of this paper.

For this paper, the digital twin refers to a digital asset that exists alongside the physical asset during its operational life, providing insight into and feedback on the physical asset's performance and health. Thus, the focus is on the DTI, with the potential to aggregate data into a DTA for the gearbox design being considered, and within the DTE set up by Hexagon.

In respect of the physical asset across its life, nothing is more important about its performance than its ability to function, i.e., reliability, and for CAE, nothing is of greater importance than to be able to predict the reliability of a product being designed. Thus, for this study, whilst gearbox noise, efficiency, and thermal behavior may be of interest, the primary interest is fatigue and reliability.

Working with the OEM

Hexagon has been working on in-service digital twins with a number of different manufacturers of ground vehicles, extending across different noncompeting industries. This paper is based on a collaboration with one company in particular, a world-renowned manufacturer of ground vehicles. For reference, the vehicles are ICE driven and the gearboxes have several discrete ratios.

This project has gathered a wealth of data, all of it derived from the operation of these vehicles and processed by Hexagon using its digital twin. To protect the interests of its client (the OEM), minimal data is displayed. Nonetheless, the narrative, insight, conclusions and ambitions from the study are the same as for the OEM, whose principal engineers have read and approved the text of this paper prior to its submission.

Building the Cloud-Based Digital Twin

Whilst the DTP is not the focus of this paper, the technical methods used owe their origins from the DTP. During the design phase a designer must carry out calculations to confirm that the gearbox is fit for purpose, and in this respect durability/reliability is the most

important consideration. The prediction of gearbox reliability does not start from a clean sheet. Gearbox fatigue has been a subject of mathematical methods that have been developed over the years and implemented in standards (ISO 6336 for gears, ISO 16281 for bearings [Ref. 2]) that have become universally implemented.

Additionally, the digital twin has included many of the refinements that have been proven to be essential in the prediction of gear and bearing performance over recent decades. Housing stiffness has been shown to impact gear and bearing misalignment and hence life (Ref. 3), and this is included; likewise, gear micro-geometry is introduced to accommodate misalignment from system deflections, impacting gear stress and fatigue; finally, bearing internal load-sharing, pre-load, and misalignment are also included. All these influences are part of the commercial software package, Romax *Enduro*, which has been marketed under various Romax names since its release in 1994 and which was acquired by Hexagon in 2020. Romax *Enduro* is principally used during the design phase of the gearbox, i.e., as a DTP.

Both ISO 16281 and ISO 6336 output component fatigue damage. This does not predict failure. Rather, 100% damage for the L10 life of bearings indicates 10 percent failure, whereas 100 percent damage (a safety factor of 1.0) for gears indicates 1% failure.

Being a long-term user of Romax as a DTP, the OEM had a confirmed model of the gearbox which could be used for the digital twin study. This model had been used in the design of the gearbox in question (i.e., a *design twin*), and a *design duty* cycle had been established by the OEM with the intention of representing the usage pattern that the vehicles would see during an anticipated working life.

However, the OEM has strong ambitions for using data to learn more about their applications and to derive a competitive advantage. In recent years, the OEM has installed on its standard production vehicles the instrumentation that is necessary to transmit to the Cloud significant quantities of controlled area network (CAN) data. It is important to note that this setup was established to understand the vehicle as a whole, not just the gearbox—this gearbox digital twin work simply worked with data that was already being downloaded. Of this CAN data being downloaded, the following data were available at a frequency of 1Hz:

- Engine speed
- Engine torque
- Selected ratio
- Gearbox oil temperature

It is obvious how this data can be used as an import to define an "in-service duty cycle," against which component fatigue calculations can be carried out. Indeed, Romax has been able to import time domain data for fatigue calculations for over 15 years. However, this project provided additional challenges.

The first was to set everything on the cloud and to have it operating without human intervention or human interaction. This is required because, in the end, the digital twin would need to process the data from many thousands of vehicles. The digital twin was set up such that the data was transferred and processed daily for each vehicle. Discussions did take place regarding having more (and less) frequent data transfer; however, it was decided that daily processing would provide the best balance between cost/complexity and insight.

Data integration, the ability to pull data across the cloud and integrate different solutions, was also required. In this respect, Hexagon has assembled a team that spans across its different offerings, combining Xalt Integration with Romax. This now handled by Nexus, Hexagon's open digital reality platform for manufacturing that is developed to provide connectivity and interoperability across all aspects of design, manufacturing, metrology and in-service operation for all Hexagon's client industries.

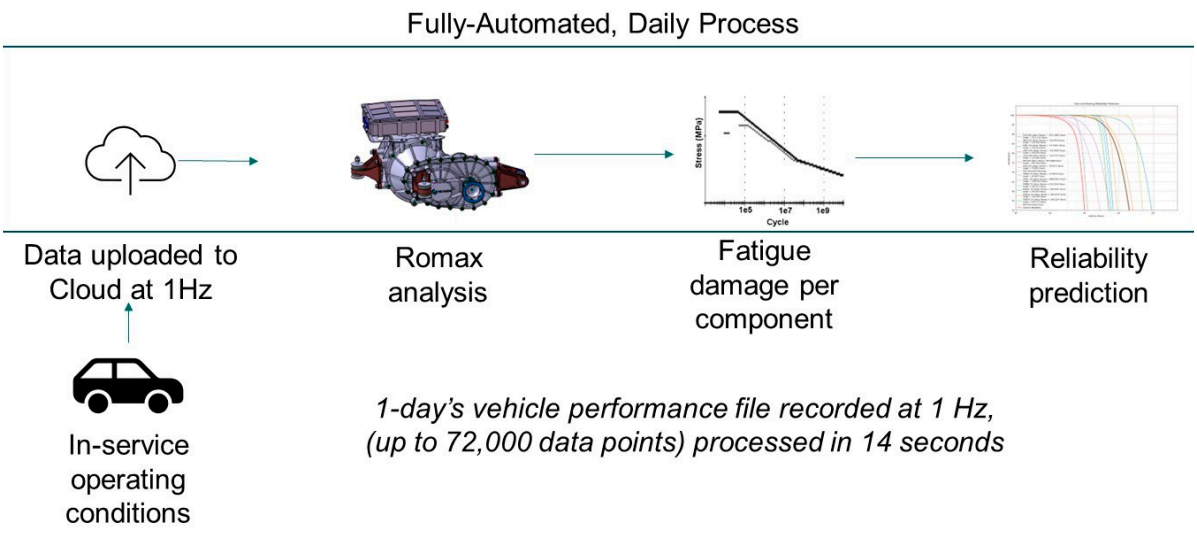


Figure 1—Flow diagram illustrating the processing of CAN data from the vehicle.

Hexagon successfully built the digital twin and as of the end of December 2022, it had successfully processed eight months' worth of data from 10 different test vehicles, with more being processed each day. The fact of the digital twin's successful operation is noteworthy. However, of greater interest is what the acquired data has already revealed in terms of how to approach the reliability engineering of gearboxes. This is to be the focus of the rest of the paper.

Predicting Gearbox Reliability

Challenges in Predicting Bearing Reliability

As has been stated, it is possible to calculate the fatigue damage for the gears (contact and bending) according to ISO 6336 and for the bearings according to ISO 16128. 100 percent damage pertains to a 1 percent failure rate for the gears and a 10 percent failure rate for the bearings. The conversion from fatigue damage to reliability for bearings was discussed at length in a paper (Ref. 4) by the same author at the CTI International Congress and Expo in Novi, MI, on 23–25 May 2023.

The paper identifies that the Digital Twin took the most 'official' recommendation for the reliability characteristic of the rolling element bearings, i.e., the reliability factor A1 from ISO. Fundamental to this is a Weibull shape parameter (β) of 1.5.

However, the paper also identified that there is substantial reason to question this data, owing to large variations in recommended values of β from different sources. GE (Ref. 5) proposes values that range from 0.7 to 3.5, whilst Bertsche and Lechner (Ref. 6) propose 1.1 to 1.35. Meanwhile, a globally renowned aerospace manufacturer (Ref. 7) claims values as high as 4.0.

The differences in these values are not simply of academic interest—they have a massive impact on the predicted failure rates of gearboxes. With such a wide range of values of β available, the net ends up being cast so wide that pretty much *any* observed outcome could be said to correlate with one or other of the quoted reliability models.

The CTI paper identified and quantified a key source of variability—that of the duty cycle. A fleet of 10 vehicles was monitored for a period of eight months, with their usage data recorded at a rate of 1 Hz. Without the Digital Twin, these vehicles would have been assumed to have identical usage patterns. Through simulation, the paper was able to quantify the error, i.e., the reduction, in observed Weibull shape parameter that would have occurred if the failure analysis of the fleet was carried out against time and not damage; that is to say, ignoring the duty cycle of each vehicle against including it in the analysis.

The analysis showed that if a value of β=1.5 is the correct descriptor of bearing reliability, failing to account for the variation in vehicle usage would mean the fleet would appear to fail according to a value of β=0.67. Even if bearings are, in fact, much more reliable, with a value of β=4.0, this makes no difference and, again, the fleet would appear to fail according to a value of β=0.68.

This analysis shows the absolute importance of monitoring the usage of each vehicle if the prediction of component reliability is to make any sense. This was impractical/uneconomic in the past, however, with recent advances in data acquisition, a far more rigorous approach to component reliability analysis now becomes possible. Therefore, our attention should turn to what would be used for gear reliability.

Sources of Data for Gear Reliability

There is a wide range of sources for values on gear reliability, and unfortunately, the picture appears even more confusing than it is for bearings. For a start, different studies (using different data sets) conclude that different reliability models provide the best fit. Some references use the Weibull shape parameter, some use standard deviations in strength, and some use lognormal distributions. Additionally, there is the provision (sometimes applied, sometimes not) of different models for contact and bending, and also for conditions above and below the endurance limit.

Nonetheless, it is useful to see all the different reference data in one place. Much of this has been taken from the *Gear Solutions* paper by Dr. Hein et al., (Ref. 8) from February 2020, but more have been added from other sources.

One clear difficulty in comparing these values comes from the fact that they are presented in different forms. By presenting the values in the form of a Weibull shape parameter, the results directly give a variation in failure against time. By presenting a standard deviation

Reference (and date)	Contact	Bending
Gleason (1965) [Ref. 9]	s.d.=23% (inferred from graph of S-N curves)	
Stahl (1999) [Ref. 10]	Limited Life: β=3.2	Limited Life: lognormal slog= 0.06–0.13
	Endurance: s.d.=3.5%	Endurance: 3.4% peened; 6.0% unpeened
Hofmann (2003) [Ref. 11]	s.d.=3.0%	
Bertsche and Lechner (2004) [Ref. 6]	β=1.1-1.5	β=1.2–2.2
AGMA (2004) [Ref. 12]	s.d.=18% (inferred from table of reliability factors)	
GE (2023) [5]	β=0.5–6.0	

Table 1—Gear reliability data from a range of published sources.

in strength, the source is indicating a normal distribution in strength which indirectly implies a variation in failure against time

Converting Reliability Guidelines into a Common Format and Comparing Them

To make sense of these values, they need to be converted to a "common currency," and within this study, it was decided to convert to Weibull shape parameter. The approach taken by Hexagon contained several assumptions, and whilst alternative assumptions could have been made, Hexagon does not believe that they would affect the overall outcome of the study.

First, the data for the standard deviation in strength was converted to an equivalent Weibull shape parameter. A graphical representation can be seen in Figure 2. The S-N curve from the standards (ISO and AGMA) refers to the 1 percent failure rate. Assuming a normal distribution and using the standard deviation in strength, a distribution in strength can be implied.

A hypothetical population of gears with this distribution in strength was generated numerically, and their resulting failure points were calculated. The limited life part of the S-N curve for contact for case-carburized gears was used. This was because case carburized gears are most common, contact failures are more common than bending failures and the greatest number of gear fatigue tests have focused on this part of the S-N curve, owing to the greater ease in achieving failures.

Figure 3 shows the data arising from the FZG data for the full set of data. This shows that a normal distribution in strength, projected onto the time axis using the S-N curve of ISO 6336, does not give a perfect Weibull distribution. This pattern was also seen for all the other values used.

It was decided to concentrate on the earlier sections of the population, since it is unlikely that a complete population of gears would be allowed to fail in service. By concentrating on the first 50 percent of failures, a closer match to Weibull could be achieved and a clearer value for β.

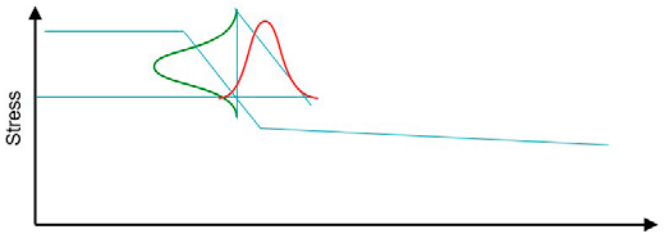


Figure 2—Graphical illustration of the conversion between a distribution in strength to a distribution in life.

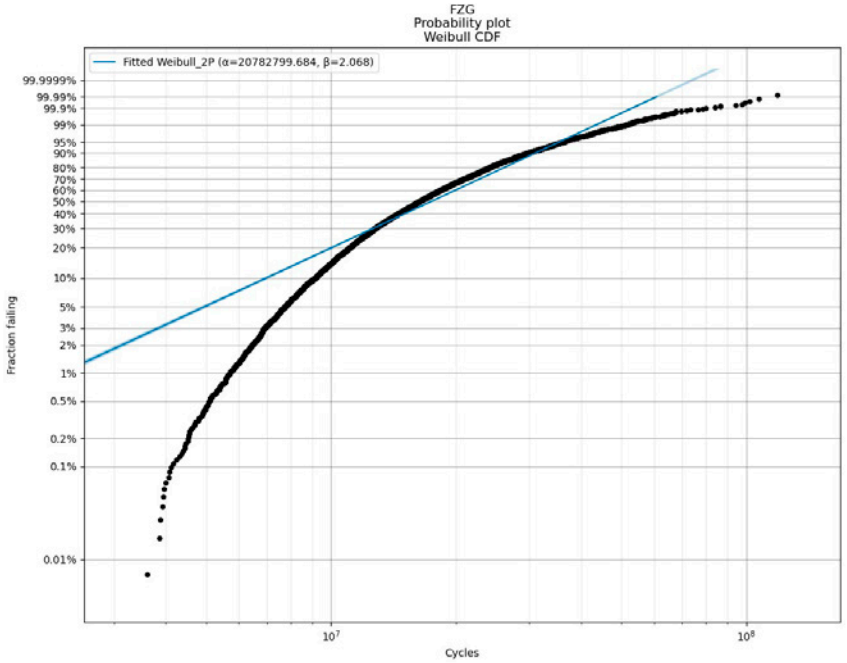


Figure 3—Derivation of equivalent Weibull shape parameter using the data from Stahl (Ref. 10), for the whole population.

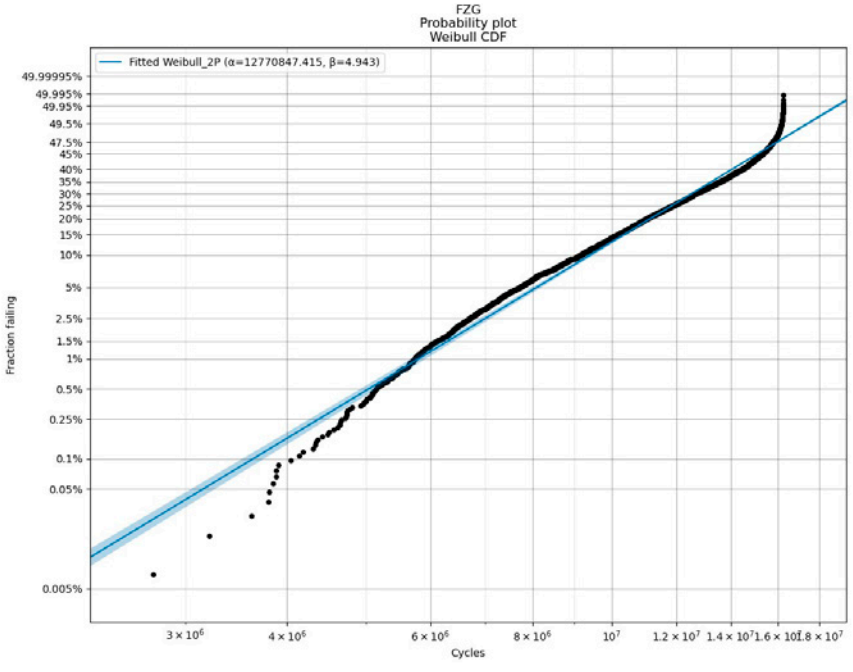


Figure 4—Derivation of equivalent Weibull shape parameter using the data from Stahl (Ref. 10), for the first 50 percent of the population.

At this point, a "sense check" can be made. Given a standard deviation of 3.5 percent of the mean and 2.326 standard deviations between the mean (50 percent failure) and 1 percent failure, this means that the mean strength of the population (and hence the gear that provides the point that crosses the 50 percent point on the y axis) is 8.14 percent higher than the strength of the gear that sits at y=1 percent. Using the slope of the S-N curve for contact from ISO (13.22) this indicates that the mean life should be approximately 3.0 times the life for 1 percent. Inspection of the graph indicates that the results (5.5e6 cycles for 1 percent; 1.6e7 cycles for 50 percent) match what is expected.

The corresponding analysis using the data from AGMA (Ref. 12) and Gleason (Ref. 9) can be seen in Figure 5 and Figure 6 respectively.

Thus, we can take Table 2 and complete it with values that allow comparison on a like-for-like basis, at least for Contact.

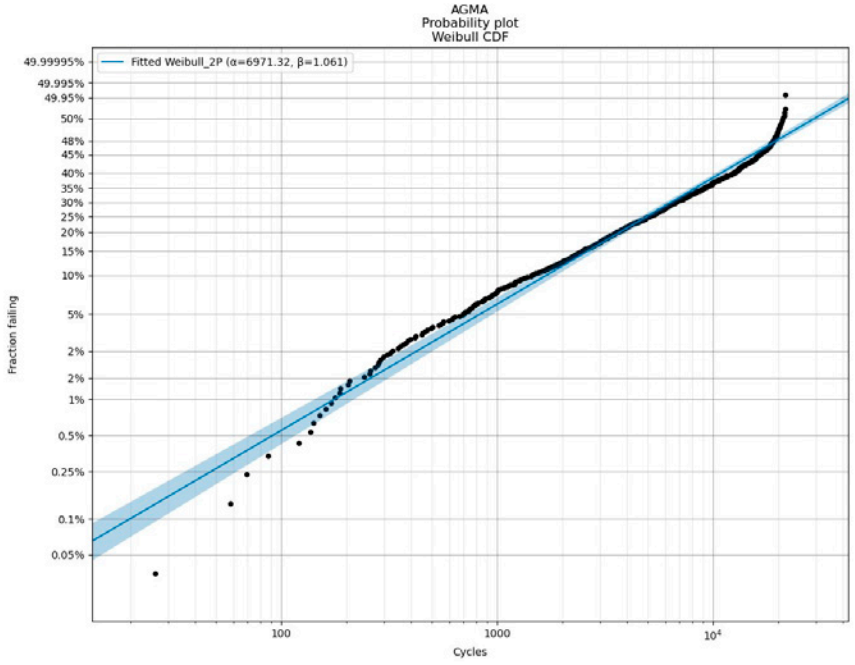


Figure 5—Derivation of equivalent Weibull shape parameter using the data from AGMA (Ref. 12), for the first 50 percent of the population.

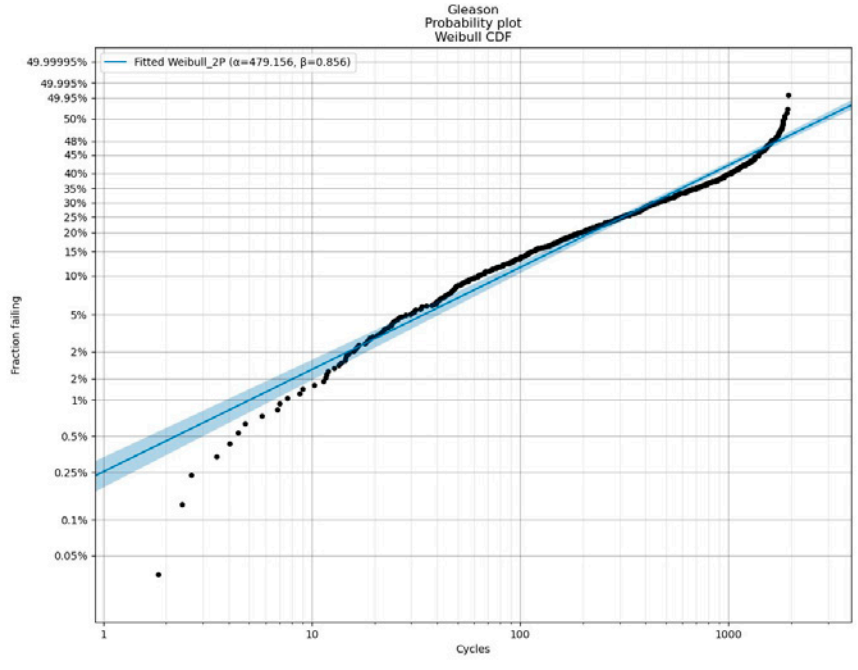


Figure 6—Derivation of equivalent Weibull shape parameter using the data from Gleason (Ref. 9) for the first 50 percent of the population.

Reference (and date)	Value of β for Contact
Gleason (1965) [Ref. 9]	0.85
Stahl (1999) [Ref. 10]	Limited Life=3.2
	Endurance=4.95
Hofmann (2003) [Ref. 11]	5.7
Bertsche and Lechner (2004) [Ref. 6]	1.1–1.5
AGMA (2004) [Ref. 12]	1.06
GE (2023) [Ref. 5]	0.5–6.0

Table 2—Gear reliability data from a range of published sources, converted to equivalent Weibull shape parameters (β), for contact.

Understanding the Varying Guidelines in Gear Reliability

So, we end up with a wide range of different values for β, starting with 0.85 for Gleason (Ref. 9), 1.06 for AGMA (Ref. 12), 1.1 from Bertsche and Lechner (Ref. 6), extending up to 4.9 from Stahl (Ref. 10) and as high as 6.0 from GE (Ref. 5). This is an extraordinary range. It is not just an aspect of "academic interest"—if a design engineer has a system for which the reliability needs to be calculated, the biggest impact on the result will not be the use of AGMA or ISO, or the method for calculating misalignment, or how KHBeta is calculated; The single main determining factor affecting the reliability result becomes which data a given engineer choses in order to extrapolate from the predicted life for the 1 percent failure rate to the predicted reliability of the population.

This can be illustrated in Figure 7, where the same nominal life for

1 percent is used and the reliability of the population is predicted using the various values of β derived from the various public sources. The problem with the lower values of β is clear—there is an enormous variation across the population. For the FZG data, the 80 percent failure point (20 percent reliability) is only ~3 times the 1 percent failure point, but for AGMA it is ~120 times, and for Gleason it is ~400 times.

Consider the implications of using the AGMA and Gleason data. If the purpose of the calculation is to predict when a gear will fail, the result becomes so uncertain that realistically no insight is possible, and the calculation is essentially meaningless. If the purpose is to check observed failure rates against predicted failure rates, the net ends up being cast so wide that pretty much 'any' observed outcome could be said to correlate with one or other of the quoted reliability models.

Another problem arises when using some of the data (Ref. 10) in that different behavior is described above and below the endurance limit. This may accurately reflect the results derived from the testing of gears in laboratory conditions, where each gear is subject to constant loading which is targeted to be in either limited life or high cycle regimes. However, if a gear is subject to in-service loading that includes both high cycle and limited life regimes, how is this to be considered? What happens if we have a mix of 80 percent/20 percent, 20 percent/80 percent, 60 percent/40 percent? If we have a loading that is just above the endurance limit for 1 percent of the population, do we assume it to be below the endurance limit (and this requires a different reliability model) for the remaining 99 percent of the population?

The result of this wide variation in results (and the subsequent uncertainty regarding differing behavior above and below the endurance limit) means that engineers tend to take the relatively comfortable approach of predicting "indicative" reliability, saying something "is as durable/reliable as the last design we did." However, if this is the case then CAE in general is profoundly guilty of what could be described as "over-promising and under-delivering." The promise has always been that product performance can be predicted so that failure modes can be understood, and "quantified trade-offs" carried out with confidence. In the case of gear reliability, these trade-offs would include:

- How will my failure rate increase (Δ percent) if I decrease my center distance (Δ mm), thereby saving weight and material?
- What are the chances that the gearbox will fail if I run it for another 1,000 hours?

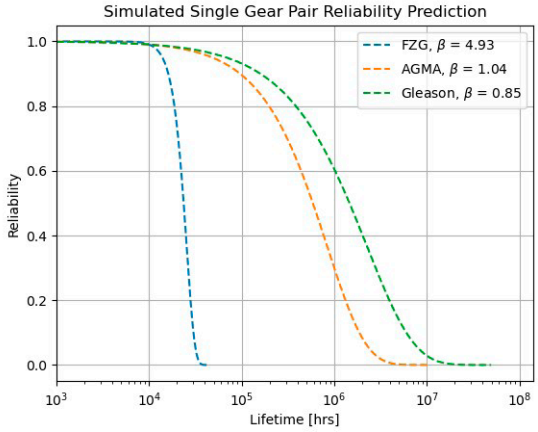


Figure 7—Representative plot of the reliability of a whole population of gears using different values for the Weibull shape parameter.

Instead, design engineers tend to approach these considerations more in the form of:

- If we go below center distance "X" we will exceed the safety factor that we have typically used for this application
- Whilst some of our gearboxes have continued to be used beyond this point, we do not have enough confidence to know whether this is suitable

This raises two questions:

- Why has this happened?
- What should we do about it?

How Did This Variability Arise?

By reflecting on its work with different companies and research organizations over the last 30 years in different industries, Hexagon believes there are two reasons for this range of values, and that understanding these can help indicate what the best solution is moving forward.

The first thing to recognize is that, to a certain extent, variability has dropped (and values of β have improved) over time. The Gleason data (Ref. 9) is from 1965 whereas the higher values are more recent. It is to be expected that over time the cleanliness of steels and the quality control of the manufacturing processes (heat treatment, grit blasting, shot peening, etc.) has improved, leading to a reduction in the variability of the strength as well as an improvement in overall strength. Certain academics have also suggested this as an observation (Ref. 11).

The other aspect is to look at where these values were derived from. In some instances (Refs. 10, 11), the data comes from test programs from university laboratories, where carefully designed test rigs with high levels of stiffness and alignment are used to test gears that are carefully manufactured and inspected, using consistent and carefully monitored loads. The cycles to failure of each gear would have been carefully recorded. Therefore, the variability of the gear lives could be put down to variations in the material properties alone.

In other instances (Refs. 5, 6), the values would have been based on observations from in-service gears. In these instances, many more factors affect gear reliability which is unlikely to have been measured.

Housing stiffness has been known to affect gear misalignment and hence gear stress for many years (Ref. 3), however, such studies may well not have been able to account for this factor, and in any case production gearbox housings are subject to variations in wall thickness and this will not have been accounted for.

Gear microgeometry is known to affect gear stress and hence durability, and most design engineers account for this by using the nominal (target) microgeometry for their prediction of gear durability. However, variations from the nominal exist, and while it is possible to measure gear geometry and import the actual tooth profile for use in the stress calculation (Ref. 13), it is reasonable to assume that these influences were also not included.

Thus, we see that whilst the values arising from university laboratories account for the variation in gear material strength alone, other values account for a much wider set of variables, factors that are known to affect gear durability but are unlikely to have been known for any given failed gear. These include:

- Gear microgeometry variations
- Gear misalignment variations, owing to variations in housing stiffness and gear alignment tolerances
- Variations in loading
- Potential for inconsistent lubrication, lubricant degradation, water ingress, etc.

During the execution of this digital twin work, Hexagon was able to acquire usage data from many vehicles that were subject to nominally identical operating environments. A study (Ref. 4) was carried out, focusing on bearings (bearings were chosen because these were found to be the components most likely to fail) to account for the impact of not knowing the loading conditions if the Weibull analysis were to be performed to determine the reliability of bearings.

This study showed that, no matter how high the actual value of β is for the bearings (i.e., a predictable failure), if the failure analysis is carried out against time and not damage, the study would deduce a much lower value of β (i.e., an unpredictable failure). This shows how the failure to include in analysis factors that substantially affect a component/system can lead to the incorrect conclusion that the component/system's reliability is profoundly unpredictable.

Figure 8 gives a graphical representation of what Hexagon believes is happening for gears, and where the variation in values of β comes from. Variability in material strength alone may well correspond to a β of ~5.0, and a quite "peaky" distribution in reliability, but when unknown factors are included, this distribution gets flattened, so that when many significant factors are left unaccounted for, the observer is left with what appears to be a profoundly unpredictable system.

In this situation, it is unsurprising that design engineers will err on the side of caution, basing new designs on old design practices rather than seeking optimum designs with full confidence in quantifiable trade-offs.

How Should This Data Be Used?

This insight indicates how to move forward with future developments. Reliability predictions must start somewhere, and the best indication is that the variability indicated by the university studies (Refs. 10, 11) properly identify the variability of strength of modern gear materials. This gives an "upper limit" on the predictability of in-service applications since it is not possible for any production gearbox to be as tightly controlled, or to have as much data as a research laboratory, in terms of manufacturing, inspection, assembly, and loading.

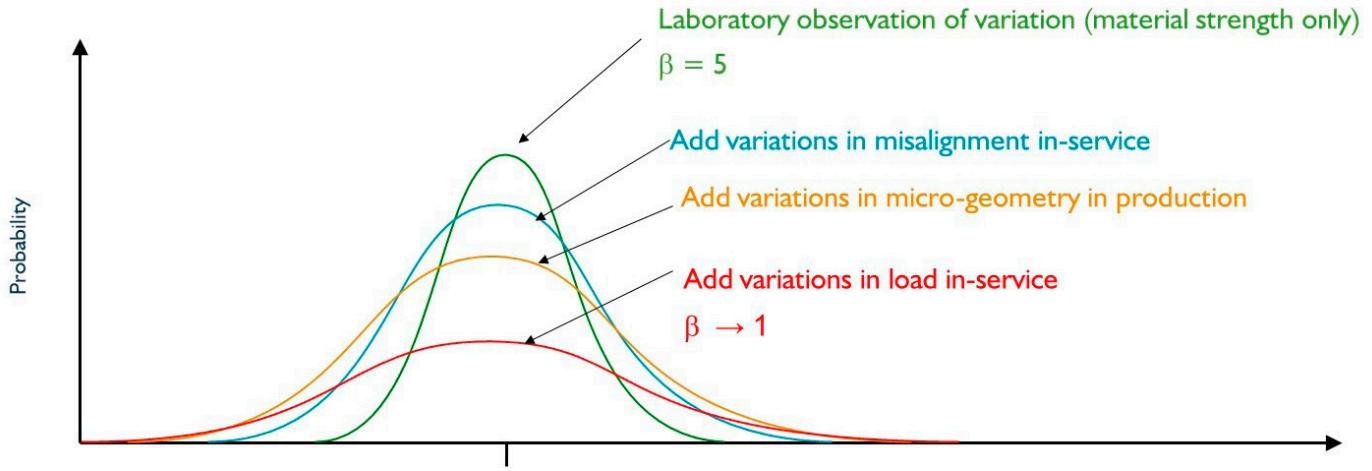


Figure 8—Illustration of how the inclusion/exclusion of various factors in a reliability analysis affects the resulting value of β.

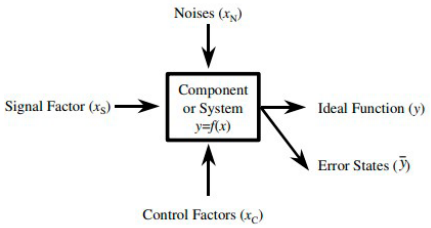


Figure 9—The p-diagram to describe an engineering system or component (Ref. 14).

This paper has shown how various influences that affect the durability of gearboxes push the observed failure rate towards randomness if they are not accounted for, and in effect, this determines what data should be used in the prediction of gearbox reliability. Load spectrum, gear geometry, and gear alignment are all examples of these influences.

Therefore, if any of these factors are known, or are tightly controlled, then there will be less scatter imparted on the life of the gearbox components, and a higher value of β can be used. If these factors are not known, or they are poorly controlled, then a lower value of β should be used.

Broadly speaking, any prediction of reliability must account for as many of the variables that affect reliability as possible. When working on Failure Mode Avoidance, Tim Davis (Ref. 14) extended the work of Taguchi, Miscke, and Phadke to take signal factors and noise factors into account (see Figure 9). In this instance, there is a danger that if the signal-to-noise ratio decreases, it becomes difficult to achieve the ideal function of the system, and error states occur.

The analogy for gearboxes is clear—the ideal function is reliable operation and component failure is an error state. Hexagon's digital twin work has shown how vehicle usage can be a noise but with the correct setup can be converted to a signal factor. Put another way, it is converted from an unknown to a known.

Within the framework of this digital twin, Hexagon has sought to convert one major factor (load spectrum) from an unknown to a known, from a noise to a signal factor. In the absence of reasons to the contrary, the digital twin uses the recommendations from Stahl (Ref. 10) from the limited life for all loads, with different models for contact and bending. Furthermore, any Weibull analysis of failed gearboxes should provide decent clarity regarding the behavior of the population as a whole.

On the other hand, if the load spectrum is assumed and not measured, the analysis carried out by Hexagon implies that a very different approach to reliability should be considered, for example, Bertsche and Lechner (Ref. 6). In this case, it is unlikely that a Weibull analysis of failed gearboxes will provide credible insight into the reasons for such failures.

Nonetheless, the digital twin, with the ability to record the load spectrum for every gearbox, provides the framework for the future of reliability engineering of gearboxes. Hexagon is working with a number of companies that are routinely harvesting vehicle usage data from substantial quantities of their vehicles. By feeding this data into best-practice CAE tools, unprecedented accuracy can be achieved in the prediction of component and system reliability.

However, more could be achieved. As it stands, there would still be assumptions that could be improved upon. For example, every OEM has values for the allowable bending and contact stresses of its materials. These values substantially affect any predictions of reliability, yet even though they are affected by a company's suppliers, machining, heat treatment, and quality control, often the 'reference' data from ISO 6336 Part 5 is used.

With the cost of data acquisition plummeting, Hexagon believes we will start to see large-scale data acquisition and failure recording. When combined in a disciplined manner, this would yield unprecedented insight into the durability and reliability of gearbox systems, an insight that could be fed back to engineers for reuse in the design of the next generation of vehicles. Effectively, a

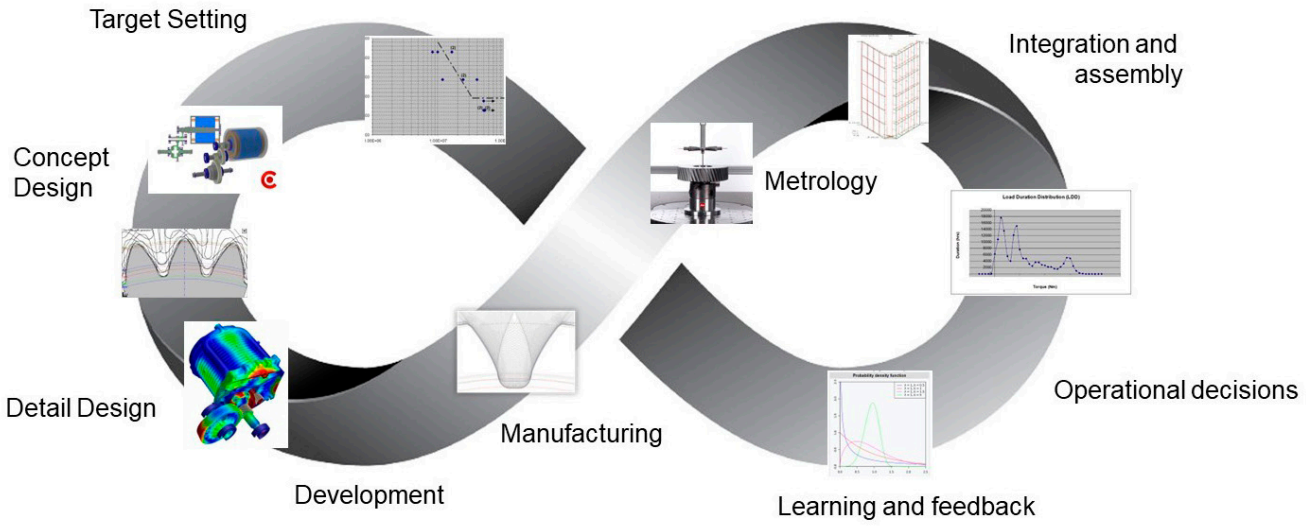


Figure 10—An illustration of the complete digital thread for gears.

"digital thread" as shown in Figure 10, would be complete. This is one of the ambitions of Nexus.

This paper talks about digital twins, but there are other fashionable terms, too. The internet of things (IoT), big data, and AI are often discussed, yet it is not always clear how they will deliver benefits. The proposal for data acquisition, failure recording, and correlation is an example of how such fashionable ideas can be applied in an achievable manner to gearbox engineering to deliver benefits in terms of reduced cost, reduced risk, faster development times, reduced material usage, longer gearbox life, and improved sustainability.

Hexagon does not propose discarding the wealth of knowledge that is encapsulated in standards such as ISO 6336, but rather building upon these standards and refining them based on the evidence provided by the usage and failure patterns identified in each application. Some major OEMs already make changes to the standards for their benefit and based on their data, thereby giving them a commercial advantage. This is set to accelerate massively.

Further comparisons are intriguing. Stahl's data (Ref. 8) was based on 509 gear tests. Soon, Hexagon's Digital Twin will be extended to cover more than 10,000 gearboxes, each with more than 10 gears, each one effectively an individual test sample since its usage profile will be monitored throughout its life.

On one hand, Stahl's data is more useful since it is available today, and all 509 gears are assumed to have failed and contributed to the statistical analysis, whereas the vast majority of the 100,000+ gears under study in the digital twin will not fail. Additionally, even the early failures are not expected for a considerable period.

However, the failure analysis arising from such a digital twin would be focused on a specific application, a specific supply chain, a specific production line with its heat treatment, lubricant selection, etc. Furthermore, over time the number of gearboxes under study will expand another one or two orders of magnitude (perhaps more), and the failure data will start to stack up. When this happens the statistical significance of the data arising from such a process, and hence its validity and accuracy, will start to dwarf that available from the university research programs that have supplied it to date. All of this will deliver a clear benefit to industry, to the users of such vehicles, and to the economy and environment.

Stahl's data is already 24 years old. Compared to the alternatives, the time to results for the digital twin described here is probably not so onerous.

Conclusion

The term *digital twin* has often been spoken about, but rarely has it been seen to be put into operation and to deliver value in practice. Likewise, terms such as *IoT* and *big data* may have delivered value when tracking people's browsing habits and targeting advertising, but there has seemed to be little relevance to gearbox engineering.

Recent work by Hexagon shows that this is changing. In collaboration with a world-renowned vehicle manufacturer, it has developed and put into service a cloud-based digital twin for a multispeed gearbox. This digital twin predicts gear and bearing fatigue and reliability, accounting for all the same influences on component fatigue as are included in state-of-the-art design analysis, but in a process that runs automatically, requiring no human interaction or intervention.

In converting from durability (percentage damage, safety factor) to reliability (failure rate), data has been referenced from various sources. However, these different sources have been shown to have widely varying values which, if used in the prediction of gearbox reliability, would lead to huge variations in the results depending on which reference was used.

It has been argued that part of this variation is due to the passage of time, and part of it is due to the difference between research laboratory testing programs and observation from industrial usage patterns. The former tightly controls many of the factors that affect gear life (loading conditions, alignment, etc.) which are either assumed or left unknown in industrial applications.

The key to useful gear reliability predictions is to maximize the signal-to-noise ratio, and in practice, this means measuring as many of the factors that affect gear life as possible. In the past, this has not been practical. However, due to recent developments, we are starting to see large programs of data acquisitions by leading vehicle companies. In the short term, this work will use current reference data on reliability to predict when gearboxes are likely to fail; over time, once proportions of the gearbox population have actually failed, the observed failure rate can be compared with the predicted failure rate and adjustments made.

The future of gear reliability prediction is starting to take shape. Manufacturers will be able to collect precise usage data on tens of thousands, probably millions of gears, and match this against failure data. Even though the failure rates will be small, the number of samples will be statistically significant, and will eventually be orders of magnitude greater than the number of samples that have been used to derive current reference data. Furthermore, each company's data will be based on its application and production processes, rather than general gear applications. Rather than fresh attempts to rewrite gear analysis methods, these will be minor tweaks to the current gear rating standards but will provide vastly greater confidence in the results.

PTE

Barry James has worked in power transmissions engineering for over 30 years. The majority has been with Romax, now part of Hexagon, where he leads Research and Innovation in the Nexus and Design and Engineering business units.

Louis Long received his BS in Mechanical Engineering from Carnegie Mellon University in Pittsburgh and began his career as a Suspension Design Engineer at Chrysler Corp in Detroit. He is currently the Director of Business Enablement in the Americas for the System Dynamics business unit of Hexagon Design & Engineering.

Alberto Satine Gioiosa graduated from the University of Toledo in 2019 with a degree in mechanical engineering. He joined Hexagon in 2021. He is currently focused on coordinating engineering activities for the US System Dynamics team, technical support, and helping customers achieve their simulation goals through projects for durability, efficiency, and NVH analysis.

References

1. Grieves, M., 2016, "Origins of the Digital Twin Concept," DOI: 10.13140/RG.2.2.26367.61609.
2. ISO/TS 16281:2008, Rolling bearings—Methods for calculating the modified reference rating life for universally loaded bearings.
3. James, B. et al., May 2000, "Predicting the effects of housing flexibility and bearing stiffness on gear misalignment and transmission noise using a fully-coupled non-linear hyperstatic analysis," C577/005/2000, Proceedings of the Institution of Mechanical Engineers, May 2000.
4. James, B. and Long, L., May 2023, "Demonstrating a Cloud-based Gearbox Digital Twin using telematics data for reliability predictions," CTI USA Symposium, 24–25 May 2023, Novi, MI.
5. Distribution Types | Predix APM | GE Digital.
6. Bertsche, B. and Lechner, G., 2004, *Reliability in Automotive and Mechanical Engineering—Determination of Reliability Levels for Components and Systems* (German: "Zuverlässigkeit im Fahrzeug- und Maschinenbau - Ermittlung von Bauteil- und System-Zuverlässigkeiten"), 3rd edition, Springer (publisher), Berlin, Germany.
7. Private conversation during technical and commercial discussions.
8. Hein, M. et al., "Reliability of Gears: Determination of Statistically Validated Material Strength Numbers," *Gear Solutions*, February 2020.
9. "The Strength of Bevel and Hypoid Gears," Gleason, 1965.
10. Stahl, K., 1999, "Life-time statistics (final report)—Statistical methods for estimation of the life-time and reliability of components and exemplary application for gears" (German: "Lebensdauerstatistik (Abschlussbericht) – Statistische Methoden zur Beurteilung von Bauteillebensdauer und Zuverlässigkeit und ihre beispielhafte Anwendung auf die Zahnräder"), IGF Nr. 11154, FVA-Nr. 304/I, Issue 580, Research Association for Drive Technology (FVA), Frankfurt/Main, Germany.
11. Private conversation with Professor Dieter Hofmann, Newcastle University, circa 2003.
12. ANSI/AGMA, 2004, "Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth," ANSI/AGMA 2101-D04.
13. James, B., Hughes, S., 2022, "Developing a digital thread linking gear design to manufacturing simulation and metrology," VDI Wissenforum, Munich, 12 September 2022.
14. Davis, T., 2004, "Measuring Robustness as a Parameter in a Transfer Function," SAE 2004-01-1130.

B&D INDUSTRIAL

Acquires American Gear & Engineering, Inc.

B&D Industrial recently acquired American Gear & Engineering, Inc. (American Gear), a premier gear manufacturing organization located in Westland, MI. This strategic move marks a significant step in B&D Industrial's commitment to vertical integration, enabling the company to provide an expanded range of offerings and greater value to its customers. *Gear Technology* recently sat down with Brian Davis, co-CEO of B&D Industrial to discuss the acquisition.

"B & D Industrial started in 1947 as a general MRO/PT distribution business in Georgia. In the late 80s, early 90s, we got into gearbox repair which led into field service, maintenance, outsourcing including installations, inspection, alignments, Davis said. Primarily tied to bearings, gearing, and couplings.

The distribution business serves Georgia, Florida, North and South Carolina, a little bit in Tennessee. The company focuses on bearings and transmission, electrical, material handling, etc. B&D Industrial really promotes value-added business on the distribution side, according to Davis.

The service division supports gearing maintenance and repair shops in Macon and Savannah, GA, West Monroe, LA, and Tacoma, WA. Adding to this list is the acquisition of American Gear, located in Westland, MI.

American Gear Acquisition

American Gear, known for its exceptional quality and innovative manufacturing techniques in the gear industry, will bring a wealth of expertise and capabilities to B&D Industrial. The acquisition also includes Tech Tool Company, Inc., a complementary gear rack manufacturer. Aligned with B&D Industrial's mission to offer comprehensive solutions to its customer base, this acquisition further establishes its position as a leader in the industrial sector.

"B&D Industrial has been a consumer of gearing in gearboxes and field service jobs, providing gearing for paper and pulp mills. This acquisition gives us a little more control in this area and gives us some advantages on pricing, delivery, etc.—the things our customers are looking for," Davis said.

It also gives B & D Industrial a new customer base in gearing.

"American Gear does a lot in gear cutting and tooling, nearly 40 years of experience in areas like gear wear, gear/rack replacement and maintenance and repair. This opens additional industrial segments we haven't been involved with before as well as additional open gearing capabilities," Davis continued.

"The integration of American Gear into the B&D Industrial family represents a pivotal moment in our journey to provide unparalleled value and comprehensive solutions to our customers." Davis said. "Over the last four decades, American Gear has been synonymous with excellence, and we look forward to continuing that tradition and building upon the legacy they have established."

The acquisition of American Gear by B&D Industrial is expected to deliver significant benefits to customers of both companies, including enhanced product offerings, expanded technical expertise and improved service capabilities.

"Joining forces with B&D Industrial opens up a new chapter for American Gear," said Jeff Emerson, founder of American Gear. "We are excited about the opportunities this presents for both our employees and our customers. B&D Industrial's extensive network and resources will allow us to grow and exceed the evolving needs of the industries we serve."

B&D Industrial's value proposition is expertise and knowledge and the goal is to bring that technical reliability to its customers.

"This adds another level to our gearing business, an additional engineering skillset to the portfolio," Davis added. "The hope is to augment what American Gear

currently does and provide additional support to help the business grow in the future."

Vertical Integration

Also, as a part of B&D Industrial's vertical integration strategy, the organization recently divested its subsidiary company Scale Systems Inc. to System Scale based in Indianapolis, Indiana. With this acquisition, System Scale will be the largest Mettler Toledo distributor in the United States, opening more career paths and growth opportunities for employees.

"System Scale is excited to further our mission to create lasting value for our customers," said Mike Sale, CEO of System Scale. "New growth will help us serve more local communities, now throughout Georgia and our expanding coverage in Tennessee. Like Scale Systems, we're proud to be an employee-owned company that empowers local management at all our locations. Customers can expect the same great service and quality products, and we're dedicated to making the transition as smooth as possible for our customers and team."

Field Service Evolution

"We've evolved over 35 years and will continue to evolve from a service standpoint. We want to emphasize productivity and reliability moving forward," Davis said.

As far as the future of the bearing and gear drive industries, acquiring skilled workers on the service side will continue to be an incredible challenge.

"We invest in new machines and machine shops and finding mechanics, engineers, machinists, it's difficult to acquire the right personnel with the right skillsets, especially if you're looking for a more practical than theoretical approach," Davis said.

B&D Industrial's field service team is committed to solving customer challenges in areas like inspection, reliability, vibration, alignment, rotating equipment, precision maintenance, AC/DC drives commissioning and field machining.

bdindustrial.com

GKN AUTOMOTIVE
Expands Role for Dr. Clare Wyatt

GKN Automotive has expanded the role of current Chief Communications and Sustainability Officer, Dr. Clare Wyatt to include the global human resource's function. With immediate effect, Dr. Wyatt will take the role of chief people, communications and sustainability officer.

Dr. Wyatt joined GKN Automotive as chief communications officer in January 2020, with her role expanding in 2022 to encompass sustainability. Over the past 18 months, she has developed the company's global sustainability strategy, driven by the business' corporate purpose – to drive a cleaner, more sustainable world. Last month, the company's net zero targets were validated by the independent Science-Based Targets initiative.

With the addition of the human resource function to Dr. Wyatt's remit, she will seek to align and further strengthen the three core functions, building on the existing collaboration between the teams. With 'Our People' as one of four pillars driving our sustainability framework, Dr. Wyatt has already played a pivotal role in further developing the company's approach to encouraging our talent to reach their full potential and encouraging a safety-focused and inclusive culture.

Dr. Clare Wyatt comments: "Our people are at the heart of GKN Automotive, helping us to develop and deliver market-leading products and technologies. Inspiring our team to reach their full potential, while also attracting the next generation of talent will keep us at the forefront of a rapidly evolving industry. I am delighted to take on this new challenge."

Markus Bannert, CEO of GKN Automotive, comments: "As a global business of 25,000 people, we place the highest value on our team to drive business success. With Clare's knowledge and expertise in the company, and a clear focus driven by our company purpose, she is exceptionally well-positioned to enhance and accelerate our people strategy."

gknautomotive.com

MOTION
Agrees to Purchase Two Fluid Power Companies

Motion Industries, Inc. has signed a definitive purchase agreement to acquire the operating assets of Perfetto Manufacturing and SER Hydraulics.

The affiliated organizations are well-established, with Perfetto in business since 1986 and SER Hydraulics since 1978. Located in Sudbury, Canada, each has grown to provide engineered solutions, service and equipment for hydraulic/pneumatic cylinders, complex power units and other assets used in fluid power systems throughout the area, which is central to the mining, agricultural and forestry industries. The dual acquisition will expand and improve Motion's services to these and other heavy-industry customers.

"After more than 30 successful years in business, we want to thank our loyal customers and employees for contributing to our success," said Gerald Perfetto Sr., owner. "The Motion team is committed to continued investment in the business, which will bring great opportunities for our customers, employees, and the communities in which we work and live. We couldn't be more pleased with the interest that Motion has taken in our business and wish everyone continued success."

"We look forward to welcoming these two terrific organizations, especially the talented employees," said Randy Breaux, president of GPC North America. "These world-class experts

will be key to our market growth strategy, and we look forward to extending our position together as a premier leader in industrial solutions."

motion.com

EATON'S

Ben Sheen Elected to GRI at Penn State Board of Trustees

Eaton recently announced that Ben Sheen, chief engineer, Eaton's Mobility Group, was recently elected to the Board of Trustees for the Gear Research Institute (GRI) at Penn State University. The GRI is affiliated with the American Society of Mechanical Engineers (ASME) and the American Gear Manufacturers Association (AGMA) to conduct research and development, consulting, and analysis for gear related needs.

"I am honored to be elected as a member of this prestigious board," Sheen said. "This is a great opportunity to continue to grow as an engineer and help develop industry-leading mobility solutions and technologies, including electrified vehicle transmissions, reduction gearing and differentials."

Sheen, who holds a bachelor's degree in mechanical engineering from the University of Wyoming, is currently responsible for supporting new product development and manufacturing capabilities within Eaton's ePowertrain Business Unit. His 20-year career with Eaton began with its Truck Group's heavy-duty transmission site in Shenandoah, Iowa, and for the past 13 years he worked at the Mobility Group headquarters in Galesburg, Michigan. His accomplishments include certifications within Six Sigma (Blackbelt) and Shainin RedX, AGMA Advanced Gear Engineering Certificate and multiple U.S. patents.

The GRI is an independent not-for-profit corporation, registered in the state of Pennsylvania. Over the past three decades, a significant amount of research and test data has been accumulated by GRI and published in many reports for sponsors. Previously published reports are available to members of the Gear Research Institute on a restricted basis.

eaton.com

ZF

Invests in Next Generation Mobility Technologies

ZF continues its pursuit of Next Generation Mobility across passenger car as well as the spectrum of light, medium and heavy-duty commercial vehicles with a planned $500 million investment in its Gray Court, South Carolina, facility. Offering everything from traditional ICE to e-mobility technologies, for both passenger car and commercial vehicle applications, ZF Gray Court is officially the company's first North American flex manufacturing facility.

Since its inception in 2010, the story of Gray Court is one of continuous growth through the introduction of high quality and highly advanced technologies for the mobility industry. "As the industries we serve evolve, so too does ZF Gray Court, which is once again at the center of mobility transformation," explained ZF Board Member, Stephan von Schuckmann. "ZF Gray Court is our North American premier flex manufacturing facility – producing technologies for today and tomorrow, but also for both passenger vehicles as well as commercial vehicles. This site is our first ever to mirror the transition that the industry and the world is now navigating."

Through this planned investment, ZF will be adding new product lines in Gray Court over the next several years, including the launch of the 8HP Gen4 PHEV already on the BMW 7 Series and X5.

Through PHEV technology, drivers are offered pure electric driving, and in addition, a highly efficient internal combustion system. "For today's drivers this means they can contribute to a greener planet while reaping the benefits of increased fuel economy without having to rely on a charging infrastructure – it's really a win-win," von Schuckmann added. "ZF PHEV transmissions are currently produced in Germany, but I'm excited to announce that for our North American customers, this product will be manufactured in Gray Court beginning in 2025, as part of our local-for-local strategy. However, this is just one part of our vision, ZF plans to enter the next phase of transformation, as we seek federal funding."

Powerful electric motors are integrated into the transmission housing of the ZF 8HP Gen4, enabling pure electric driving performance of up to 160 kilowatts and a torque of 450 Nm – almost double the previous 8-speed generation. "Depending on the battery dimensions of our customers, we can easily achieve an all-electric range of more than 75 miles with our latest-generation 8-speed plug-in hybrid, and further electric range means reduced CO2 emissions," explained von Schuckmann. "The 8HP Gen4 PHEV's efficiency means electric drives will be the main propulsion for plug-in hybrids in the future compared to combustion engines and will significantly reduce the 'range anxiety' of many drivers on the road to electrified mobility. And if it should be a longer journey, then the efficient combustion engine supports the electric drive to reach the desired destination in a relaxed manner."

zf.com

April 22–26

Hannover Messe 2024

From drive and fluid technology to digital platforms and IT security to industrial internet and robotics, Hannover Messe (Hannover, Germany) reflects the manufacturing industry's broad scope and provides important economic and social impulses every year. Additional 2024 topics include 5G technology, additive manufacturing, automation, sensors, e-mobility, material handling and more. An industry in the process of change needs to keep moving – and being moved. New requirements call for innovative developments toward drive solutions that are increasingly intelligent, flexible, and efficient. Components networked down to the smallest actuator enable ever more powerful, perfectly orchestrated workflows.

powertransmission.com/events/978-hannover-messe-2024

May 6–9

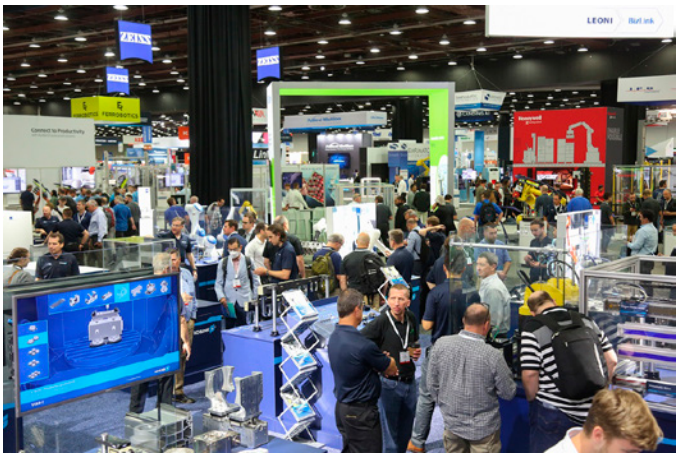
Cleanpower 2024

Cleanpower 2024 (Minneapolis, MN.) grows businesses by gathering key decision makers and stakeholders across the wind, solar, storage, hydrogen, and transmission industries for discussion, deal making, networking and a whole lot of fun. The trade show not only brings together the different technologies that make up the renewables mix; onshore wind, offshore wind, solar, storage, and transmission but also the different segments within the industries; manufacturers, construction firms, owner operators, utilities, financial firms, corporate buyers and more. Cleanpower will feature the latest products, services and technologies coming to the renewable energy industry.

powertransmission.com/events/977-cleanpower-2024

May 6–9

Automate 2024



Between intimate workshops with industry giants, keynotes, networking events, innovation competitions and live demonstrations, Automate 2024 (Chicago) offers comprehensive automation education and cutting-edge robotics, vision, AI, motion control and other technologies. Automate delivers the latest innovations in manufacturing automation technology from more than 600 leading exhibitors. Each day also offers inspirational keynote sessions and theater presentations to help attendees find the best solutions for their unique business needs.

powertransmission.com/events/941-automate-2024

May 15–16

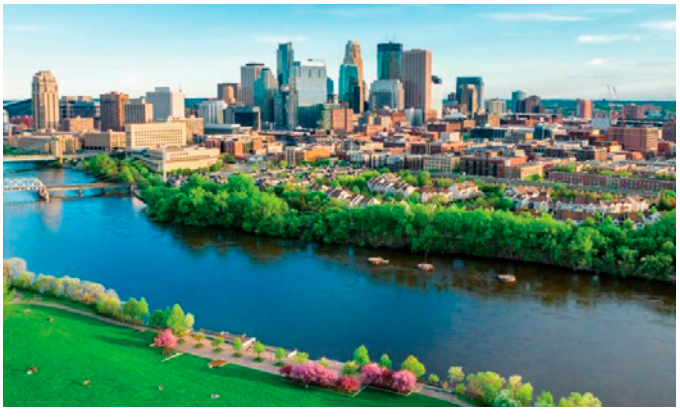
CTI Symposium USA 2024

CO2 reduction is critical for automotive drivetrain. Here the battery electric drive using renewable energy is the focus. What can we do to increase efficiency and reliability, reduce cost and at the same time reduce upstream CO2? At CTI Symposium USA 2024 (Novi, MI) the automotive industry discusses the challenges it faces and promising strategies. Latest solutions in the fields of electric drives, power electronics, battery systems, e-machines as well as the manufacturing of these components and supply chain improvements are presented. For the bigger picture market and consumer research results as well as infrastructure related topics supplement the exchange of expertise.

powertransmission.com/events/942-cti-symposium-usa-2024

May 19–23

STLE Annual Meeting and Exhibition



STLE is celebrating 80 years of technical excellence and innovation during the event. The STLE Annual Meeting & Exhibition (Minneapolis, MN) will feature over 500 technical presentations, a trade show with over 100 exhibitors, a Commercial Marketing Forum, 13 industry-specific education courses, discussion panels on technical and market trends, and more.

powertransmission.com/articles/9674-stle-opens-registration-for-2024-annual-meeting-and-exhibition

AD INDEX

CALL FOR PAPERS!

Are you sitting on an idea for a technical paper but wondering where to present it? Do you have one already written, sitting on your desk, gathering machine dust?
How about *Power Transmission Engineering*? We are always looking for gearing- and power transmission component-relevant technical papers for publication in the magazine and in its digital version. Having your work appear in *Power Transmission Engineering* guarantees you an audience of the most experienced and discriminating industry players. You say your work has not been peer-reviewed? Not a problem, as we are lucky — and thankful — to have on-hand some of the most experienced and brilliant minds in the industry — our technical editors. So if your work "passes muster" and is published, you'll know you were reviewed by the best — and most demanding.
Chances are you'll be creating the paper under the auspices of the company for whom you work or own, or for one of the various industry-relevant associations. That means they as well will bask in the reflected glory that accrues with publication in *Power Transmission Engineering*.
For publication guidelines and more information, please contact Randy Stott at *stott@agma.org*

Power Transmission Engineering®

FREE SUBSCRIPTION

☐ Renew my subscription ☐ NEW subscriber

24PTEALL

☐ **YES** I want to receive/continue to receive ***PTE*** ☐ NO

Name _____

Job Title _____

Company Name _____

Company Address _____

City _____

State _____

Zip Code _____

Signature: _____
(required)

Date: _____

Please send
☐ PRINT Version
☐ DIGITAL Version (E-mail required)
E-MAIL: _____
☐ BOTH Print and Digital
*You can OPT OUT at any time.

How isTHIS LOCATION involved with power transmission products?
(Check all that apply)

☐ WE **MAKE** power transmission products
☐ WE **BUY** power transmission products
☐ WE **SELL** power transmission products (distributors, sales reps, etc.)
☐ WE **DESIGN** products with power transmission components in them
☐ Other (please describe) _____

What is your company's principal product or service?

_____

Your mailing label on the cover looks like this:

X/Y - means you have recieved a complimentary copy. Please complete this form to continue receiving your FREE copy of PTE.

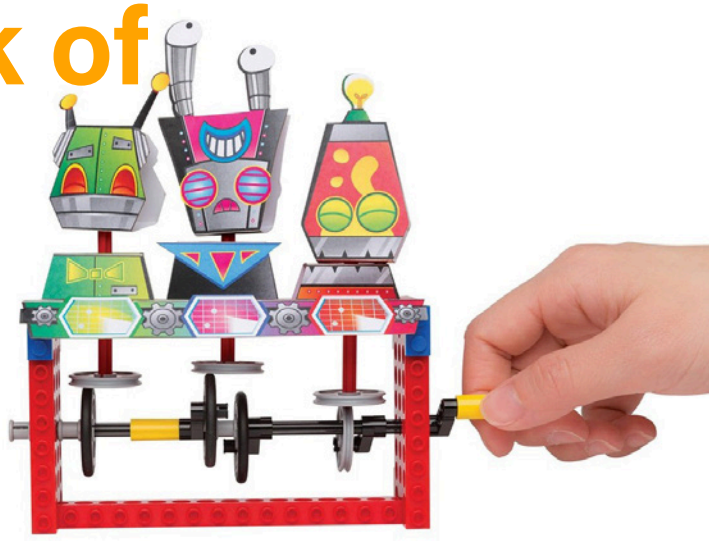
Q14 (shown above) - means you have 14 issues remaining in your subscription (a NEW subscription has 16 issues).

Q1 - means you have 1 remaining issue before your PTE subscription expires. Please complete this form to renew.

MAIL to: 1001 N. Fairfax St, Suite 500, Alexandria, VA 22314 USA | SCAN to: *subscribe@powertransmission.com* | FAX to: 1.847.437.6618

The Wheelwork of the Universe

Aaron Fagan, Senior Editor



Hanging above my desk is a quote from Nikola Tesla that reads, "Every living being is an engine geared to the wheelwork of the universe." What this means to me evolves daily. For example, I was walking the dogs over the weekend, and I noticed a gray piece of plastic on the lawn. My first instinct was it must go to a toy of some kind. I have been trying to imagine all week what it might go to. If it is a car part, where would it go? Perhaps it is a piece from one of the landscaping crew's equipment? And then—in the very synchronistic wheelwork of nature—I was researching one thing and discovered something else: Gear Bots by LEGO. My search was over. Lo and behold, pictured on the box among its component friends were the very type of piece I spotted on the lawn.

Besides offering parents a space from proclamations of boredom, toy science kits engage kids' innate curiosity with the world through hands-on experiments with cause and effect, the beating heart of the scientific method. Philosopher Alvin Toffler wrote in his 1970 book *Future Shock*, "The illiterate of the twenty-first century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn." A good science kit embodies true experimentation in that it will transcend prescriptive outcomes—it will leave room for open exploration of the problems they face. Kids like that may be future engineers.

For Related Articles Search
education
at powertransmission.com

STEM kits like Gear Bots not only provide entertainment but also facilitate learning about engineering fundamentals through interactive activities. I grew up with Erector Set, Girder and Panel, and Tinkertoy which were relatively static compared to the toys of today. While this STEM kit is targeted to kids 8 to 12, who—regardless of age—wouldn't want to make a DJ octopus spinning records, a yeti with punching arms, or a pterodactyl with flapping wings?

According to the Gear Bots literature, each model includes a papercraft character kids can fold and link with the corresponding LEGO elements. There's a detailed 64-page book with clear instructions to help kids bring their kinetic creatures to life—plus a host of STEM content to take in about axles, cams, cranks, and more engineering fundamentals in everyday machines.

In contemplating Tesla's assertion about every living being as an engine geared to the universe's wheelwork, one can't help but find serendipitous connections in the everyday. That walk with my dogs and a mundane encounter with a piece of plastic sparked a cascade of thoughts about its origin and purpose.

This seemingly trivial incident led me down a rabbit hole of speculation, only to be pleasantly surprised by a synchronistic revelation during a seemingly unrelated research session. It's moments like these that underscore the interconnectedness of our experiences and the boundless potential for discovery, echoing the sentiment of Alvin Toffler regarding the importance of adaptability and continuous learning in an ever-changing world.

As we immerse ourselves in the realm of STEM education, fostering curiosity and hands-on exploration through innovative kits like Gear Bots, we not only entertain but also empower the engineers and problem solvers of tomorrow. Lest we forget, it was while on a walk in a park, reciting lines from Goethe's poem *Faustus* to himself that Tesla had the revelation for the design of his alternating current (AC) motor.

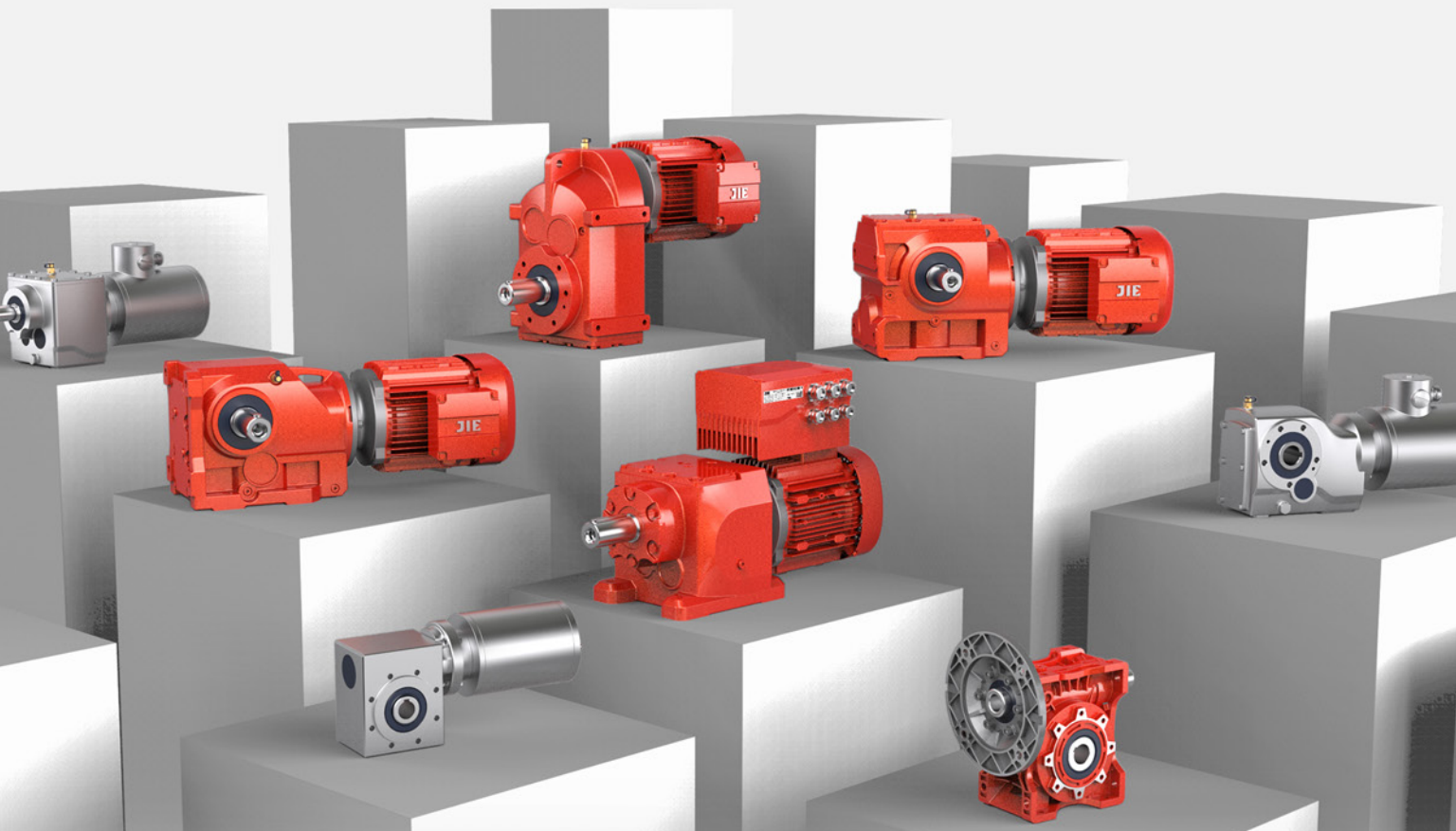
PTE

JIE
JDRIVE

PTDA Channeling the Power of Industry

IP69K

- Quick Delivery
- Great Service
- Top Quality



Options are Worm gear unit; Helical inline, Parallel shaft, Helical bevel and Helical worm gearmotor; Available in aluminum, cast iron and stainless steel housing.

JIE USA INC.

493 Mission St. Carol Stream, IL 60188
www.jie-drives.com | Info@jie-drives.com | +1 630 580 9986

NEW MINIATURE BALL SCREWS

MADE IN USA

Solve Supply Chain Issues

with State of the Art CNC Roll Threaded Ball Screws

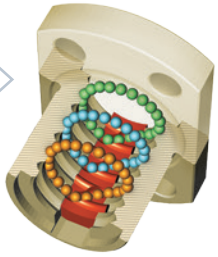
Miniature ball screw assemblies from PBC Linear have a range of leads with small screw diameters for high precision linear motion. Our ball screws are precision-rolled to achieve lead accuracy and consistency over the full length of the screw.

Manufactured at our Midwest headquarters allows for short lead times in compared to overseas sources.

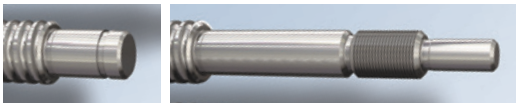
- **Available Sizes** - Flange and Cylindrical Nuts

  6 x 1 | 8 x 1 | 8 x 2 | 8 x 2.5 | 10 x 2

- **Internal Ball Screw Return System** — Multiliner System



- **Machined Journals**

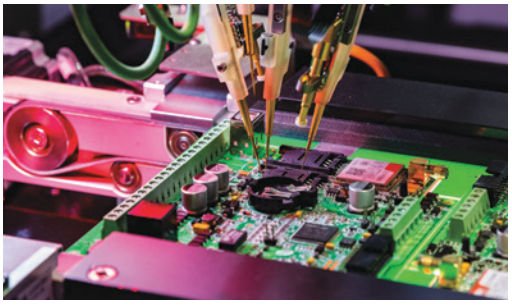


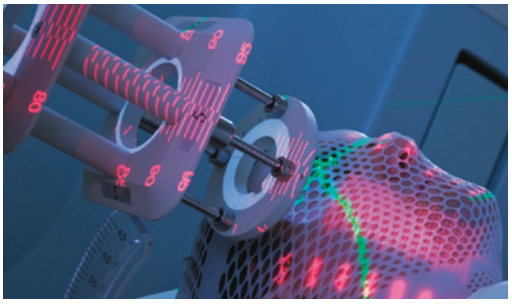
- **State of the Art Metrology and Inspection**

- **Integrated Ball Screw Motors**
  - NEMA 08, 11, 14, 17, & 23

- **Customization Available**

- **Applications**





Request Your FREE Ball Screw Sample

bit.ly/BallScrew2024

PBC Linear®

6402 E. Rockton Road, Roscoe • Illinois 61073 USA • +1.800.962.8979 • pbclinear.com